Disorders of agency and self in the schizophrenic spectrum: from phenomenological models to empirical data

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Georgina Torbet, M.Sc.

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Gutchter/innen: Prof. Dr. Norbert Kathmann, Prof. Dr. Michael Pauen, Dr. Tanja Endrass

Präsident der Humboldt-Universität zu Berlin:
Prof. Dr. Jan-Hendrik Olbertz

Dekan der Lebenswissenschaftliche Fakultät:
Prof. Dr. Richard Lucius

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Hiermit erkläre ich an Eides statt, dass ich die vorliegende Arbeit selbstständig und ohne unerlaubte Hilfe verfasst habe;

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Georgina Torbet

Berlin, den 29. April 2014

Abstract

Schizophrenia is a complex condition which manifests in a broad variety of symptoms, including alterations in the subjective experience of one as a self within the world, which are termed self disorders. Experiences similar to these clinical schizophrenia symptoms can also be found in non-clinical populations, such as in individuals high in schizotypy, which is a psychometric measure of a dimension of uncommon experiences and behaviours. There are also known to be symptoms related to disorders of agency in the schizophrenia spectrum, such as delusions of control, in which the feeling of control over one's actions is disrupted. The aim of this thesis was to examine the relationship between disorders of self and disorders of agency in the schizophrenic spectrum.

The thesis consists of three papers spanning from a theoretical background to two behavioural studies. The first paper is a theoretical examination of the experimental paradigms which are used for measuring agency. It also discusses how apparently contradictory empirical findings regarding disorders of agency in schizophrenia can be understood. It lays the theoretical background for the experimental papers.

The second paper refers to a behavioural study of 50 participants using a novel semi-structured interview, based upon a phenomenological conception of self disorder. It addresses whether self disorder symptoms typically found in schizophrenia are also found in a non-clinical high-schizotypy population and whether these symptoms can be measured reliably with this technique. The measurement of self disorders in this format was found to have good inter-rater reliability, and these symptoms were indeed found more among high-schizotypy than low-schizotypy people.

The third paper used eye tracking to examine whether the deficits in volitional saccades found in schizophrenia would also be found in 26 non-clinical high-schizotypy subjects. Comparing volitional to visually-guided saccade allows experimental manipulation of the degree of agency over the eye movement that a subject experiences. There were no significant differences in latencies between groups of high- and low-schizotypy people in any condition. However, a strong negative correlation between visually guided saccade latency and self disorder score was found. This is the first time that a link from self disorder symptoms to performance in eye movement tasks has been made.

There are both theoretical arguments and empirical evidence for a link between disorders

of self and of agency in the schizophrenic spectrum. Implications of this for both research and clinical settings will be considered. This thesis represents a novel interdisciplinary approach to the study of schizophrenia spectrum conditions by incorporating concepts of self disorder from phenomenology into experimental paradigms.

Zusammenfassung

Schizophrenie ist eine komplexe Störung, die sich in einer Vielzahl von Symptomen manifestiert. Diese schließen Änderungen in der subjektiven Wahrnehmung von sich als ein Selbst in der Welt ein, die als Selbststörungen bezeichnet werden. Wahrnehmungen, die diesen klinischen Symptomen von Schizophrenie ähneln, können auch in nicht-klinischen Populationen gefunden werden. Dazu gehören Individuen mit ausgeprägter Schizotypie, einem psychophysischen Maß einer Dimension ungewöhnlicher Wahrnehmungen und Verhaltensweisen. Es sind auch Symptome bekannt, die in Bezug zu Störungen von "Agency" (Urheberschaft) innerhalb des Schizophrenie-Spektrums stehen. Dazu gehören Wahnvorstellungen von Kontrolle, bei denen das Gefühl der Steuerung eigener Handlungen gestört ist. Das Ziel dieser Dissertation war die Untersuchung des Zusammenhanges zwischen Selbststörungen und Störungen von Agency im schizophrenen Spektrum.

Die Dissertation besteht aus drei Artikeln, die sowohl eine theoretische Abhandlung als auch zwei Verhaltensstudien umfassen. Der erste Artikel ist eine theoretische Beurteilung der experimentellen Paradigmen, die zur Messung von Agency verwendet werden. Es setzt sich auch mit dem Verständnis von scheinbar widersprüchlichen empirischen Befunden bezüglich Störungen von Agency in der Schizophrenie auseinander. Dieses Paper liefert den theoretischen Hintergrund für die beiden experimentellen Artikel.

Der zweite Artikel beschreibt eine Verhaltensstudie, in der 50 Probanden an einem semistrukturiertes Gespräch teilnahmen. Dieses Gespräch wurde mit einem eigens entwickelten Fragebogen zur Selbststörung durchgeführt, welches auf einer phenomänologischen Auffassung der Selbststörung basiert. Das Ziel dieser Studie war, zu untersuchen, ob Selbststörungssymptome, welche bei der Schizophrenie auftreten, ebenfalls in einer nicht-klinischen Population mit erhöhter Schizotypie zu finden sind. Außerdem sollte bestimmt werden, ob der neue Fragebogen Selbststörungssymptome verlässlich misst. In der Tat zeigte die Messung anhand dieses Fragebogens eine hohe Übereinstimmung zwischen verschiedenen Bewertern. Des weiteren wurden Selbststörungssymptome, wie vorhergesagt, häufiger bei Personen mit höheren Schizotypie-Werten beobachtet.

In der im dritten Artikel beschriebenen Studie wurde bei 26 Probanden Eyetracking verwendet, um zu untersuchen, ob die bei der Schizophrenie zu beobachtenden Defizite bei willentlichen Sakkaden auch bei Personen mit nicht-klinisch erhöhter Schizotypie auftreten. Der Vergleich zwischen willentlichen und visuell geführten Sakkaden ermöglicht die experimentelle Manipulation des Grades an empfundener Agency über die

Augenbewegungen. Bei den Latenzen wurden keine signifikanten Unterschiede in den experimentellen Bedingungen zwischen den Gruppen mit höherer und niedrigerer Schizotypie gefunden. Jedoch ergab sich eine starke negative Korrelation zwischen der Reaktionszeit bei visuell geführten Sakkaden und dem Grad der Selbststörung.

Mit dieser Studie wird zum ersten Mal ein Zusammenhang zwischen Selbststörungssymptomen und Verhalten in einer Augenbewegungsaufgabe nachgewiesen. Zusammenfassend gibt es also sowohl theoretische Argumente als auch empirische Belege, die für einen Zusammenhang von Selbststörungen und Störungen von Agency innerhalb des Spektrums der Schizophrenie sprechen. Implikationen für die Forschung und für den klinischen Kontext werden diskutiert. Diese Dissertation benutzt einen neuartigen interdisziplinären Ansatz zur Untersuchung von Störungen im Spektrum der Schizophrenie, indem sie experimentelle Paradigmen aus Selbststörungs-Konzepten aus der Phänomenologie ableitet.

List of original publications

Torbet, G., Reuter, B., and Kathmann, N. **Experimental methods of measuring agency: Conceptual aspects and implications for psychopathology research.** Under review, *Phenomenology & the Cognitive Sciences.*

Torbet, G., Schulze, D., Fiedler, A., Kathmann, N., and Reuter, B. **Reliability of measuring self disorders in a non-clinical population.** Submitted for publication, *Schizophrenia Research.*

Torbet, G., Kathmann, N., and Reuter, B. **Volitional and visually-guided saccades in non-clinical schizotypical populations.** In preparation for publication, *Psychophysiology.*

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List of abbreviations

CM	Comparator Model
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, fourth edition
EASE	Examination of Anomalous Self-Experience
IHM	Ipseity-Hyperreflexivity Model
SCID	Structured Clinical Interview for DSM-IV
SPQ	Schizotypal Personality Questionnaire

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1. Introduction

1.1. General comments

The current thesis represents an interdisciplinary effort to examine the underlying pathological constructs in the schizophrenic spectrum. To understand a condition as complex as schizophrenia, it can be beneficial to synthesise insights from a variety of different fields of study, which use different methodologies and theoretical models. This project includes work in both phenomenological psychiatry and experimental psychology, constructed on a base of philosophy of science. It is my hope that bringing together knowledge, methods and concepts from several fields may produce both new theories and innovative ways of testing these theories empirically.

1.2. Key concepts

1.2.1. The Schizophrenia Spectrum

The first challenge in investigating unusual experiences in mental disorders is to consider the definition, reliability and validity of the pathological condition in question. The nature of schizophrenia is a much contested topic, with some authors arguing that it exists not as a single disorder but as a group of related syndromes (Carpenter et al., 1999), and others arguing that the concept is invalid and should be discarded altogether (Read et al., 2004). The concept of a schizophrenia spectrum, with non-clinical individuals on one end and those experiencing severe symptoms on the other, has gained momentum and interest from researchers recently (Van Os et al., 2009). Conditions other than schizophrenia which may be considered part of the schizophrenia spectrum include schizotypical personality disorder, schizotypal personality disorder, schizophreniform disorder, and delusional disorders (Siever & Davis, 2004). A spectrum approach posits that signs and symptoms of schizophrenia would also be found to some extent in non-clinical people, who would not be diagnosable with schizophrenia or an other disorder.

The reporting of schizophrenia-like symptoms among non-clinical groups is of interest for reasons both theoretical and pragmatic. Theoretically speaking, the existence of symptoms considered phenemenologically paradigmatic of schizophrenia in non-clinical groups suggests that it is not the psychotic experience in and of itself which causes people to develop mental disorders, but something in the interpretation or integration of these experiences. That some

people live with some of the symptoms of schizophrenia but do not experience them as distressing or disabling to a pathological degree may be illuminating of potential protective factors against developing the disorder. Pragmatically, it can be advantageous to work with non-clinical populations in research for a number of reasons: ease of recruitment, no medication confounds, and avoiding the confound of general cognitive impairments found in schizophrenia proper.

This project focuses on non-clinical high-schizotypy populations, to examine schizotypy as a distinct entity and also to consider findings and theories which may be applicable clinically to schizophrenic populations. Schizotypy here is defined as a psychometric measure of dimension of uncommon and odd experiences and behaviours, which is correlated with the risk of developing schizophrenia (Cyhlarova & Claridge, 2005).

1.2.1.1. Schizophrenia as a disorder of self

Since its conception, schizophrenia has been characterised as a disorder of self: described as a "splitting of the psychological functions: as the disease becomes distinct, the personality loses its unity" (Bleuler, 1911). The so-called "first-rank symptoms" of schizophrenia define the blurring of the distinction between self and other (Schneider, 1959). This loss of ego-boundaries, resulting in a distorted experience of self, has been described as the fundamental experience of schizophrenia, which gives rise to all other symptoms (Sims, 1991; Kimura, 2001; Sass & Parnas, 2001).

This disordered experience of self can be seen particularly in the schizophrenic symptoms of thought insertion, in which patients believe that thoughts are being inserted into their minds by an outside agent (Schneider, 1959), and of motor passivity, in which patients believe that their bodily movements are being controlled by another (Maruff et al., 2003). These symptoms exemplify the failure to correctly identify self-produced actions and thoughts, due to a disturbance in the processing of information relating to self versus other.

Self disorder symptoms have also been observed in people who are at high risk for developing psychosis but have not yet developed a diagnosable disorder (Nelson, Thompson & Yung, 2012), suggesting that self disorder symptoms may be found on a continuum with healthy experience.

1.2.1.2. The Ipseity-Hyperreflexivity model

A recent prominent phenomenological model of schizophrenia relevant to this work is the Ipseity-Hyperreflexivity Model (IHM) (Parnas, Sass & Zahavi, 2008). This model posits two distortions of experience in schizophrenia: hyperreflexivity (excessive self-monitoring), and diminished ipseity (a reduction in the sense of self as a subject).

Hyperreflexivity describes the experience of excessive awareness of, and attendance to, the normal process of body and mind. Intense focus on a particular perception can lead to noting detail at the expense of broader context; in this case, the intense focus is turned on the self. Thoughts or sensations which would normally be experienced as part of the self appear instead as subjects of an objectifying hyper-awareness. Excessive monitoring of internal states can render these states strange or alien, such as in the abnormal bodily sensations (coenesthesias) experienced by some people with schizophrenia.

The other notion described in the IHM is loss of ipseity, or the immediate sense of "mine-ness" which accompanies our perceptions, actions and feelings. Ipseity is preflexive – it occurs as a necessary feature of being a mind, implicit in all over experience, which exists prior to reflection and judgement. In subjective experience, such as when eating an apple and experiencing the taste of it, you do not need to look for evidence to make a judgement of who is doing the tasting. It is an implicit part of the experience that it is something which happens *to you*. Hence our experiences involve a built-in reference to themselves as *our* experiences, which Zahavi and Parnas (1998) have argued constitutes a basic form of self-awareness. Ipseity is not a contingent feature of perception; rather it is the central tenet of what makes an experience subjective. Ipseity is the fundamental medium through which all perceptions and feelings are filtered, and it is that which gives rise to subjectivity and thus to a coherent sense of self.

In schizophrenia, ipseity is reduced or absent from experience, and so both the world and the body seem alien and unfamiliar. The self is no longer experienced as inhabiting a comfortable relationship to mind and body. It is this disturbed sense of self which is posited to underlie the various clinical symptoms of schizophrenia.

1.2.2. Sense of Agency

Sense of agency references to the experience of control we have over our movements and actions (Gallagher, 2007). This feeling is related to our understanding of ourselves as bodies

and as actors: as Helmholtz (1866) asked, when we see motion, how do we know that it is our eyes moving across the world, and not the world moving in front of our eyes? The challenge is to distinguish self-produced movements from movements of the outside world. We have a feeling of control over our movements, which seems natural and invisible to us in everyday life. However, this sense of agency can be disrupted, as seen in schizophrenia symptoms such as delusions of control. In fact, disruption in the experience of control has been posited to be the causal factor leading to various cognitive and social problems seen in schizophrenia (Kircher & Leube, 2003).

It must be noted that the term "agency" is used in difference ways in different fields. It can be used to denote experiences ranging from control over motor movements (e.g., moving a finger) to making decisions which affect the outcome of one's life (e.g., deciding to become a scientist). This project will focus on what could be termed “low-level” agency, referring to simple voluntary motor actions.

1.2.2.1. A note on terminology: agency and volition

The concept of volition is linked to agency in that both describe the relationship between one's willed intention and the awareness that one is causing events in the world. Volition is a term more commonly used in the psychology and cognitive neuroscience literature, in which it typically refers to our intentions to make simple, small motor movements, and the outcome of those intentions. Agency is a term more based in philosophy, which refers to the capacity of an individual to enact their intentions over the long-term, in ways that may include movements, actions and communications. Here we will consider volitionality to be a term for the short-term, small-scale aspects of agentic experience.

1.2.2.2. Feeling of agency / Judgement of agency

An important conceptual distinction in agency research is between a feeling of agency (pre-reflective feeling of actions being yours) and a judgement of agency (deciding that an action was yours after the fact) (Gallagher, 2007). Judgements of agency are reliant upon agentive experiences (i.e., experiences of feeling of agency), which are based on the mechanisms responsible for action production. Feeling of agency, however, is pre-reflexive and non-conceptual, it is a facet of experience rather than something which can be consciously reflected on.

A similar distinction is proposed by Jeannerod (2009), who describes a "subpersonal" and automatic level of action identification, unimpaired in schizophrenia, and a "personal" conscious level of what he calls "sense of agency", but which maps more closely to a "judgement of agency". Evidence here is that schizophrenic patients can make automatic compensations to their movements given distorted visual feedback (showing unimpaired automatic action awareness), but when the distortions are large they are much slower to switch to a conscious strategy (Fourneret et al., 2001, 2002). The subpersonal level controls and adapts motor movements, while the personal level provides information about high level intentions and desires of the agent.

1.3 Agency in Schizophrenia

There is evidence from both research and clinical settings that disorders of agency occur in schizophrenia. Clinically, symptoms such as motor passivity or thought insertion suggest a distortion in the feeling of agency over bodily movements or thoughts. Empirically, one example is that schizophrenia patients are more susceptible to certain bodily illusions than controls, such as the rubber hand illusion (Costantini & Haggard, 2007), in which a rubber hand is placed next to the participant's hidden hand, and both hands are stroked at the same time. This give rise to the illusion that the rubber hand belongs to the participant, as is experienced as part of their body. People with schizophrenia experience the illusion faster than healthy controls (Peled et al., 2003), suggesting a increased willingness to take ownership of external objects. This malleable sense of ownership over the body implies that the sense of agency may be similarly disrupted in schizophrenia, due to confusion regarding the distinction between self and other.

In this section, to further consider the topic of agency in schizophrenia, empirical evidence of a deficit in willed behaviour in schizophrenia is examined, specifically regarding volitional and reflexive eye movements. Next, the theoretical context is described by considering a popular neurocognitive model of agency in schizophrenia, the comparator model (Blakemore et al., 1998).

1.3.1. Empirical evidence: Reflexive and volitional eye movements

One method of measuring agency in schizophrenia is through eye tracking experiments comparing reflexive to volitional saccades. Saccades are eye movements typically

characterised by short lantencies (~200ms) and brief durations (between 20 and 120ms) (Gooding & Basso, 2008). Saccades may be classified into two types: fast reflexive, or slower volitional. However, fast saccades may not be entirely reflexive, and involve and element of volitionality (Hutton, 2008), so reflexive saccades are more accurately described as visually-guided saccades.

A long history of research into saccades in schizophrenia began with Diefendorf and Dodge in 1908. It is now generally accepted that visually-guided saccades are unimpaired in schizophrenia, but volitional saccades are slower (see Reuter & Kathmann, 2004 for a review).

Particularly notable is the antisaccade task, in which subjects fixate on a central point and a target appears to the left or to the right. Participants are instructed to not look to the target, but rather to look in the opposite direction. It is thus a task which requires inhibition of reflexive movement, as the appearance of a target induces a reflexive saccade which must be overridden by a volitional saccade in the opposite direction (Hutton & Ettinger, 2006). Patients with schizophrenia are impaired on this task, showing more errors than controls, which suggests a difficulty in inhibiting reflexive behaviours (Reuter et al., 2007).

The lack of impairment in visually-guided saccades shows that the slower volitional saccades seen in people with schizophrenia are not due to deficits in muscular movements or other limitations of eye movements. Rather, the volitional aspect specifically seems to be impaired in such a way as to make volitional movements slower than reflexive movements (Reuter et al., 2007).

In non-clinical populations, high-schizotypy individuals have been shown to make more errors on the antisaccade task than controls (Holzman et al., 1995; Gooding, 1999; O'Driscoll et al., 1998). Most investigations have found no difference in saccadic latencies on correct trials between high- and low-schizotypy participants (Aichert et al., 2012; Brenner et al., 2001; O'Driscoll et al., 1998). However, Thaker et al. (1996) found that relatives of schizophrenics showed longer latencies in antisaccade tasks than controls, but these subjects were relatives and not selected for their schizotypy level specifically.

Regarding visually-guided saccade tasks in schizotypy, most studies have found no deficit in either latencies or error rates as compared to controls (Aichert et al., 2012; Gooding, 1999; Klein et al., 2000). However, both Larrison et al. (2000) and Ettinger et al. (2005) found

shorter visually-guided saccade latencies in high-schizotypy participants.

Thus patients with schizophrenia show normal or enhanced visually-guided saccades, but impaired volitional and antisaccades. However, it is unclear the degree to which non-clinical high-schizotypy people show this same pattern of performance, and there is thus scope to further investigate volitional and visually-guided saccades in this thesis.

1.3.2. Theoretical model: The Comparator Model and its limitations

Arguably the most influential neurocognitive model of agency in schizophrenia is the Comparator Model (Blakemore et al., 1998), which posits a process through which sense of agency is reduced in schizophrenia. This model proposes that sense of agency arises from a comparison between predicted and actual sensory input. Before an action is made, the motor system generates a prediction of the sensory consequences of that action. Once the action has been made, the prediction is compared to the actual sensory feedback. If the prediction and the feedback are a match, then the subject feels themselves to be the agent of the action. In schizophrenia, an error in the prediction leads to a mismatch between the two signals. Symptoms such as delusions of control may occur as the actual sensory input of a movement does not match the predicted sensory input, so one's actions appear to be externally generated.

The model is supported by a body of empirical evidence, such as that patients with delusions of alien control are less likely to correct errors in a motor task in the absence of visual feedback (Frith & Done, 1989), showing that such patients rely on sensory feedback more in order to correct errors in movement. Also, schizophrenic people were able to tickle themselves more than healthy controls or other clinical groups (Blakemore, Smith, Steel, Johnstone, & Frith, 2000), suggesting that they are making inaccurate predictions of their own movements and hence are surprised by the movements when applied to themselves. Finally, patients with schizophrenia found it harder than healthy controls to identify when an image was of their hand or the hand of another person (Daprati et al., 1997), showing a difficulty in distinguishing between self and other.

This model would predict reduced sense of agency in schizophrenia, as a mismatch in predicted and actual feedback causes a loss of the sense of agency. However, some experiments have found an enhanced sense of agency in schizophrenia, such as the false feedback tasks of Franck et al. (2001). An image of a computer-generated hand is imposed over the subject's hand using mirrors, and movements are altered spatially or temporally and

the subject must identify whether the movement seen is their own. Patients tend to identify alien hands as belonging to them more often than healthy controls, showing an enhanced sense of agency as they are claiming ownership over an object in the world which they cannot control.

Another issue with the comparator model is that it may explain the feeling of agency, but is not sufficient to explain the judgement of agency (Synofzik et al., 2008). A difficulty is in understanding the threshold at which a difference between predicted and actual feedback indicates a mismatch - the threshold cannot be very low as subjects still identify movements as their own when manipulated spatially (Farrer et al., 2003) and correctly identify their voices when the pitch is changed (Cahill, 1996). At what point is the distinction between self-produced and other-produced actions drawn? Suggestion of a second, higher-order comparator leads to infinite regress. In order to determine what the effects of a movement are, the comparator system must already represent which movements are self-caused.

Further, although this model is often invoked to explain first rank symptoms including delusions of control and auditory hallucinations, there remain several inconsistencies between the theory and empirical findings. One would expect that a failure in the prediction of sensory consequences would cause deficits in motor control, but motor control seems to be unimpaired in schizophrenia (Waters & Badcock, 2010). Also, the model might explain why a patient believes that they are not in control of their actions, but it does not explain why they attribute agency to another person (nor why they believe any particular specific person to be responsible) (Waters & Badcock, 2010).

The comparator model is an empirically well-supported account of motor intention and action. However, it has some limitations as an explanation of disruptions of agency in schizophrenia. An amendment to the model has been proposed in the form of the multifactorial weighting model (Synofzik, 2008; Vosgerau & Synofzik, 2012), in which the comparison of predicted to actual sensory feedback is but one factor of many which is used to assess the sense of agency. Other factors include predicted visual feedback, actual visual feedback, and their comparison – here the authors differentiate visual and non-visual sensory feedback as distinct agency cues which may be present independently of each other. These factors are weighted differently depending upon their past reliability – so a cue with high variance would be less reliable, and would thus be weighted lower (Vosgerau & Synofzik, 2012). In schizophrenia, as internal predictions about sensory consequences of actions are

inaccurate (Synofzik et al., 2010), then visual information (or other posthoc sensory feedback) is weighted more strongly in the attribution of agency. In this thesis I address these issues by empirically investigating disorders of agency in the schizophrenia spectrum, and considering whether the comparator model is a sufficient explanation for these findings.

1.4 Relating disorders of self to disorders of agency

Some previous research has suggested a link between disorders of self and disorders of agency. Hauser et al. (2011) looked at the attribution of agency in schizophrenia patients, prodromal patients and healthy controls. They also assessed the level of ego disturbances and passivity phenomena in both patient groups, and found the over-attribution of events to oneself was highly correlated with the presence of passivity phenomena. It seems counter-intuitive that patients who report feeling as if someone else controls them would actually over-estimate their causal effect on the world. But the authors suggest that this may be a coping mechanism, whereby patients exaggerate their own agency to allay uncertainty about agency in ambiguous settings. Further, loss of ego boundaries highly correlated with ability to improve performance on agency attribution tasks, which the authors propose could be due to an over-reliance on external stimuli to make judgements, because of the uncertainty regarding agency that comes with loss of distinction between self and other.

The convergence of both empirical and theoretical work in cognitive science suggests that disorders of self and disorders of agency may be related or share some underlying features.

1.5. Research Questions and Hypotheses

This thesis addresses the topic of the relationship between disorders of agency and disorders of self in the schizophrenia spectrum, involving three aspects:

Question 1	How can apparently contradictory empirical findings regarding disorders of agency in schizophrenia be understood?
Aim	To review the theoretical background of empirical research into agency.

Question 2	Can the self disorder symptoms typically found in schizophrenia be measured reliably in non-clinical populations? If so, are these symptoms found in the high-schizotypy population?
Hypotheses	High-schizotypy people experience some of the same disorders of self which are seen in schizophrenia. Specifically, they are expected to show higher levels of self disorder symptoms than low-schizotypy people, and the semi-structured interview introduced will measure these symptoms reliably.

Question 3	Do high-schizotypy people show the same pattern of normal or enhanced visually-guided saccades and impaired volitional saccades as schizophrenic people? If so, are these deviances associated with self disorder experiences?
Hypotheses	High-schizotypy people are hypothesised to show a similar pattern of saccadic movements to schizophrenics: fast visually-guided saccades are unimpaired or enhanced; slower volitional saccades are impaired. Impaired volitional saccades may be correlated with degree of self disorder.

2. Methodology

In order to investigate these research questions, a theoretical consideration of the literature and two empirical studies were performed. The empirical studies were a reliability study on self disorder symptoms and an eye tracking experiment comparing volitional to visually-guided saccades. The studies used the following methodology:

2.1. Questionnaires and Screening Instruments

2.1.1. Schizotypal Personality Questionnaire (SPQ)

Schizotypy is measured in these studies using the Schizotypal Personality Questionnaire (SPQ) (Raine, 1991), a 74-item questionnaire which has been shown to have good reliability and consistent underlying factors (Calkins, Curtis, Grove & Iacono, 2004). The SPQ is based on Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV) criteria for schizotypal personality disorder (SPD) (American Psychiatric Association, 2000) but was also designed to measure schizotypal traits in non-clinical groups. It is thus a useful tool for investigation of symptoms across the schizophrenia spectrum, from several impaired clinical populations to non-clinical groups recruited from the public.

2.1.2. Examination of Anomalous Self-Experience (EASE)

The Examination of Anomalous Self-Experience (EASE) (Parnas et al., 2005) is a tool for the assessment of self disorder experiences, using a clinical interview. It is a descriptive-psychopathological checklist of 57 well-described items for aspects of self disorder experience. All items are rated on a 4-point Likert scale (0=absent, 1=questionably present, 2=present[mild], 4=present[moderate], 5=present[severe]). The items are grouped into five theoretically defined domains ("cognition and stream of consciousness", "self-awareness and presence", "bodily experiences", "demarcation/transitivism" and "existential reorientation"), each comprising a set of phenomenologically similar symptoms.

2.1.2.1. Modifying the EASE for use in a non-clinical population

The EASE was formalised into a semi-structured interview, in which each item was assigned a question. The questions were open-ended and sought to provoke the participant to discuss the experience in question. Questions applied a broad definition of the experience and participants were encouraged to discuss their experiences in their own words. Some items had

follow-up questions which asked for more specific information if the participant indicated that they were familiar with the experience in question. The interviews were conducted in German. For a list of questions used in the interview translated into English, see paper 2, Appendix.

The interviews were performed by three interviewers, who were advanced Psychology students with experience in a clinical setting. They were extensively trained on the EASE (around 30 hours of training total), including understanding the underlying phenomenological constructs of each item, building rapport with participants, and interpreting the descriptions of the participants.

Interviews were video taped, and once interviews were completed, the rating took place. The rating was performed by the interviewer and an independent second rater, who watched the videotaped interviewer and rated each item. The second rater was another of the interviewers who did not have access to the participant or to the original interviewer's notes. In addition, both the interviewer and the second rater were blind to the schizotypy score.

2.1.3. Other Assessment Instruments

Participants were checked for diagnoses of mental disorders using the German version (Wittchen, Zaudig, & Fydrich, 1997) of the Structured Clinical Interview for DSM-IV (SCID I) (Spitzer, Williams, Gibbon & First, 1994). A demographic data questionnaire of our own design was used to assess age, gender, first language, educational information, current employment, a history of neurological and psychiatric treatment, handedness, and drug and alcohol use.

2.2. Participants

We began with an internet screening of schizotypy in a large sample using the SPQ. The internet screening was advertised on mailing lists for students at the Humboldt-Universität zu Berlin and the Freie Universität Berlin, in a local newspaper, and on a public classified advertisements board. A total of 1296 participants completed the online survey, of which 428 were discarded from further analysis due to not having completed all questions, and SPQ scores for the remaining participants were then calculated. Of the remaining 868 participants, those who scored above the 90th percentile cut-off of SPQ score (≥41; N=129) or below the 10th percentile cut-off of SPQ score (≤7; N=145) were assigned to the high- and low-

schizotypy groups, respectively.

Randomly selected participants from the high- (N=30) and low-schizotypy (N=20) groups were invited to take part in an experimental session at the Psychology department of the Humboldt-Universität in Adlershof. Participants with history of head injury or neurological conditions, as assessed through self report, were excluded from the experimental session. The demographic data for the final groups was as follows: the high-schizotypy group had 23 female and 7 male participants, mean age 27.5 (SD=6.6) and mean 12.8 years in education (SD=1.7). The low-schizotypy group had 14 female and 6 male participants, mean age 32.7 (SD=11.0) and mean 12.6 years in education (SD=0.92). The larger high-schizotypy group was due to a desire to use this data for further analysis, as we expected greater variance of EASE score in this group.

2.3. Experimental Procedure

Participants were invited through email and telephone communication to attend an assessment session at the Institute for Psychology, Humboldt-Universität zu Berlin. After being informed about the conditions and aims of the study, participants completed the self-report questionnaires. The participants were then interviewed using the modified EASE interview, typically lasting 1.5 to 3 hours. The interviews were video recorded for later rating. Next, the SCID interview was conducted, and afterwards the participants took part in an eye tracking experiment.

2.3.1. Eye Tracking set-up

2.3.1.1. Apparatus

Participants sat in an eye tracking cabin in front of a monitor on which the task was presented. The lighting was kept at a low level and a chin rest and foot rest were used to reduce body movements. The 17 inch monitor was 20 inches away from the eyes of the participants. Stimuli were presented using Presentation version 16.3 (Neurobehavioural Systems, Inc) and recorded using the EyeLink system version 2.22 (SR Research).

2.3.1.2. Procedure

Blocks began with instructions presented on the screen, and in addition, the experimenter explained the conditions verbally. Each block consisted of 10 practice trials, followed by 40

actual trials. Each trial began with the participant fixating on a central cross. After 1000-2000ms (randomised per trial), a symbol was changed on screen to signal that the participant should execute an eye movement to the left or to the right. The symbols used and the direction of eye movement required differed for each block (see section 2.3.1.3). On half of trials the target for the eye movement was on the left, and on the other half it was on the right. Stimuli were presented in white on a black background. Blocks were presented in a counter-balanced order.

2.3.1.3. Experimental task

The experiment included seven different eye movement conditions, as follows (illustrated in Figure 1). Cued and uncued simple volitional saccades involved a target on either the left or right side, and a change in central stimulus, which indicated the direction in which the eye movement should be directed. In the cued condition, the direction of the instruction was indicated before the change took place, but not in the uncued condition. The cued and uncued conditions serve to distinguish subcomponents of response selection and initiation, based on previous empirical findings that people with schizophrenia are impaired on saccade initiation specifically (Reuter et al., 2007). Cued and uncued visually-guided saccades were also investigated, which were similar to the simple volitional saccades, except that there was also a change in the target stimulus at the time of central change. An antisaccade task was included in which the participants were instructed to execute an eye movement in the opposite direction to the target.

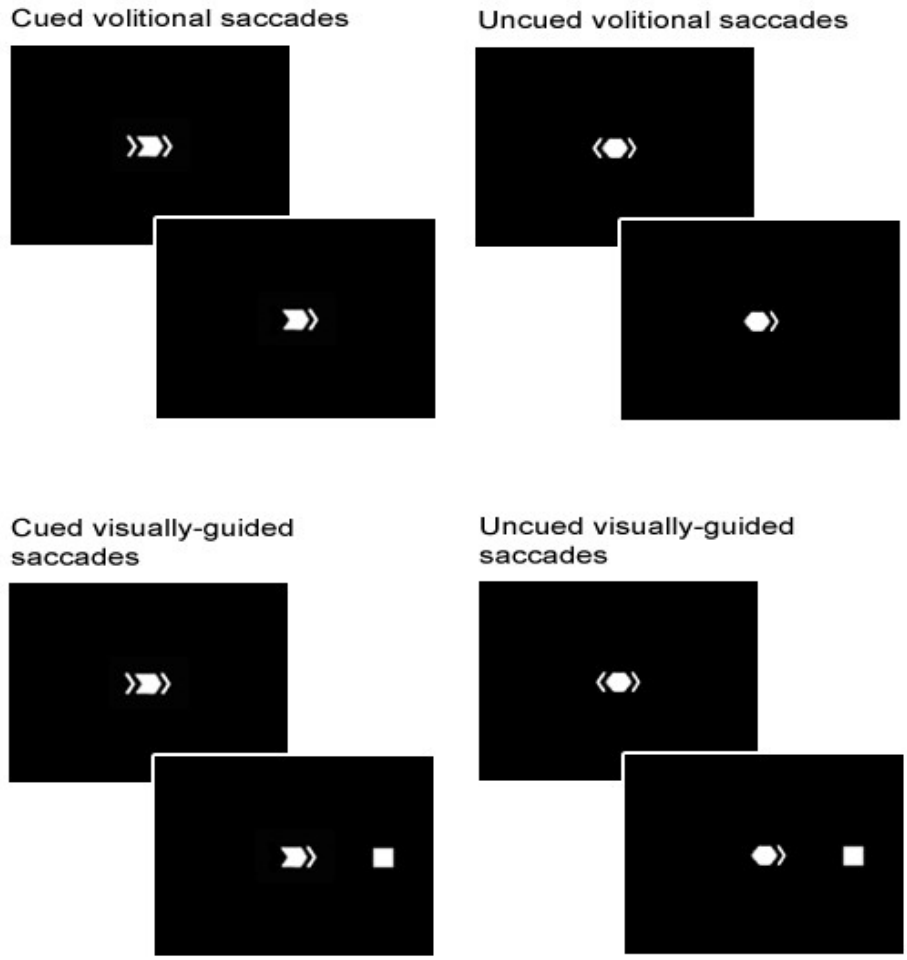

Figure 1: Representation of the task conditions (adapted from Kloft et al., 2013, with permission)

It was also considered whether experiences of volition would be effected by different sensory modalities, and to this end performance on tasks where the signal to execute a saccade was given by an auditory tone was examined. In one condition, the tone was presented simultaneously with the central change of the symbol. In another, the tone was presented alone, without a central change.

2.4. Statistical analysis

Data was analysed using SPSS 19 (IBM Corp, Armonk, NY), SR Research Data Viewer 1.10 (SR Research) and MedCalc (MedCalc software, Ostend, Belgium).

Inter-rater reliability for the interview was calculated using a quadratically weighted kappa score for the pair of ratings for each individual item. Kappa score corrects for chance agreement and takes frequency into account (Sim & Wright, 2005), making it a commonly used method for assessing agreement between raters. A weighted kappa statistic was most appropriate for measuring inter-rater reliability as the rating scale is ordinal in nature (Fleiss & Cohen, 1973; Stemler, 2004). We used a quadratic weighting as this can be interpreted as an intraclass correlation coefficient (Brenner & Kliebsch, 1996; Schuster, 2004). A general estimation of reliability was calculated by averaging individual kappa scores for each interviewee.

Participants who did not complete the eye tracking experiment (N=4), who had incomplete data (N=15) or fewer than 5 valid trials on each block (N=5) were excluded. The final remaining groups were 13 high-SPQ and 13 low-SPQ participants. Trials were excluded for meeting any of the following criteria: 1) no saccade occurred within the time window (starting 800ms before the start signal with a duration of 1200ms), 2) the subject did not fixate in the centre from 800ms onwards, 3) a blink occurred between 800 and 1000ms, 4) any recording gaps larger than 150ms occurred, 5) the saccade occurred between 200ms before and 80ms after the start signal (classified as anticipatory saccades).

The median latency of correct saccades was determined for each subject in each of the seven conditions. A one-way ANOVA was conducted comparing the effect of group (high versus low schizotypy), cue (cued versus uncued conditions), and volition (volitional versus visually-guided conditions) on saccade latencies in the five main conditions. Cases were excluded listwise. Posthoc t-tests were performed to test specific hypotheses. Correlations between EASE score and latencies were investigated using a bivariate correlation to find the

Pearson product-moment correlation. Correlations were investigated in the high-schizotypy group only, as there was large variance of EASE in the high group (M=59.46, SD=32.71) but not in the low group (M=12.46, SD=12.38).

3. Summary of Theoretical Paper and Experimental Studies

This chapter will briefly summarise the three papers which comprise this thesis. The first paper is a theoretical analysis and review of empirical methods for measuring agency, the second is a reliability study for a phenomenologically-based interview for assessing self disorders, and the third is a study into volitional and visually-guided saccades among high-schizotypy people. The complete papers can be found in section 6.

3.1. Paper 1: Experimental Methods of Measuring Agency: Conceptual aspects and implications for psychopathology research

As yet, there is no consensus regarding how agency can be measured empirically. A number of different paradigms to investigate agency are available in the literature, but no one is accepted as standard. For the sake of further research, it was beneficial to assess these paradigms and the aspects of agency which they measure. A summary of paradigms used in the literature is presented in Table 1, including a brief description of each paradigm, the findings of the paradigm in people with schizophrenia (where such investigations were performed), a notation of whether these findings indicate an enhanced or reduced sense of agency in schizophrenia, and an indication of the aspect of agency which each paradigm measures.

This allows comparison of the relationship between the aspects of agency which are measured and the paradigm's findings. Most studies which found enhanced agency in schizophrenia used paradigms which measure judgements of agency. Studies which found reduced agency in schizophrenia typically used paradigms which measured other aspects of agency, such as self versus other judgements, judgements of causation, or judgements of ownership. This demonstrates that the current theoretical conception of schizophrenia patients experiencing only a reduction in agency in insufficient to explain all the available empirical evidence. Schizophrenia patients also show enhanced agency on certain paradigms, depending upon which aspect of agency the paradigm measures.

Table 1: a summary of experimental paradigms used to measure agency

Paradigm type	Authors	Brief description	Findings in schizophrenia (where investigated)	Agency in schizo-phrenia	Type of agency
False feedback	Nielsen 1963; Sørensen 2005	Inducing alien hand experiences	-	-	Feeling of agency
	Fourneret & Jeannerod 1998	Subjects drew a line, mirrors used to make it appear distorted	-	-	Feeling of agency
Computer-ised false feedback	Franck et al. 2001	Subject move joystick, visual feedback is distorted, asked if movement is theirs	Patients claimed ownership in more extreme temporal deviations than controls	Enhanced	Judgement of agency
	Nahab et al. 2011	Virtual hand, manipulated the degree to which participants had control	-	-	Judgement of agency
	Asai and Tanno 2007	Subject control cursor on a screen, movements are manipulated spatially or temporally	High-schizotypy had weaker sense of self agency on spatially distorted trials	Reduced	Judgement of causation
	Hauser et al. 2011	Participant drummed; heard faithful or manipulated audio of their playing	Patients claimed agency over sounds even when they were computer generated	Enhanced	Judgement of causation
Agency judgement with priming	Aarts et al. 2005	Primed wheel of fortune game, participants had to judge whether a square was selected by them or by the computer	-	-	Judgement of agency
	Gentsch et al. 2012	Button press was concordant or not with information on screen, participants judged how strong the casual link between button and screen	-	-	Judgement of causation
	Damen, Baaren & Dijksterhuis 2014	Pushed buttons which produced tones, sometimes primed, asked the degree to which they caused the tones	-	-	Judgement of causation
Intentional binding	Haggard, Clark and Kalogeras 2002	Judgement of elapsed time between button press and tone	Patients show stronger binding	Enhanced	FoA / judgement of causation
	Voss et al. 2010	As above, but modified probability of tone	Patients over-rely on sensory feedback	Enhanced	Feeling of agency / judgement of causation
	Moore et al. 2013	Watched videos of another's push/tone, estimated time elapsed	Healthy subjects differed in estimates when video is same, but described as intentional	-	Judgement of other causation
Self recognition	van den Bos & Jeannerod 2002; Jeannerod et al. 2003	Participant and experimenter have gloved hands and make movements. These images are manipulated, participants are asked if hand was theirs	Patients with hallucinations or delusions of control showed more errors, mistook the experimenter's hand for theirs	Reduced	Judgement of ownership
	Blakemore et al. 2000	Can you tickle yourself? Subjects produce movements which are relayed back to them by machine, they rate sensations of ticklishness and surprise	Patients found their own movements as ticklish as movements produced by others	Reduced	Feeling of ownership
	Van Doorn, Hohwy & Symmons 2014	Used body transfer illusions in tickle paradigm above	-	-	Feeling of ownership
Action ownership	Wegner & Wheatley 1995	Participant & confederate share trackball used to select an image	-	-	Judgement causation
	Metcalfe et al.	Inputs to a computer were	Patients rated their	Enhanced	Judgement

2012	distorted by noise, participants were asked about their sense of agency and accuracy	accuracy lower on distorted trials but not their agency	of agency

3.2. Paper 2: Reliability of Measuring Self Disorders in a Non-clinical Population

Self disorder symptoms are well-recognised in phenomenological psychiatry research, and have been suggested as paradigmatic of the schizophrenic experience (Simms, 1991). However, there is a paucity of knowledge about the biological and psychological underpinnings of these symptoms. Recently, renewed interest in phenomenological methods have lead to the creation of tools for the differentiated assessment of self disorders, designed for use among the clinical schizophrenic population. One such tool, the Examination of Anomalous Self-Experience (EASE) checklist (Parnas et al., 2005), aims to assess self disorder symptoms through a clinical interview and rating of items on a descriptive checklist of psychopathological experiences. This tool was developed for use in clinical settings, and we adapted it for use among non-clinical populations.

We aimed to explore whether anomalies of self occurred in the non-clinical population, and further, whether these anomalies could be measured reliably. We used a semi-structured interview technique to assess the prevalence of self disorder symptoms in groups of high- and low-schizotypy participants. Interviews were video taped and rated by two independent raters, and the inter-rater reliability was calculated.

All items showed good reliability, scoring a kappa above 0.5. According to the classification of Landis & Koch (1977), six of the items showed moderate agreement (kappa between 0.41 and 0.60), 44 items showed substantial agreement (kappa between 0.61 and 0.80) and 22 items showed almost perfect agreement (kappa between 0.80 and 1.00). The mean kappa score for all EASE items was 0.76, showing substantial agreement between raters for the score for the whole interview. Internal consistency for the whole scale was found to be excellent (α=0.95). The average inter-item correlation for the whole scale was moderate (r=0.27).

As expected, the high-schizotypy group scored significantly higher (M=63.27, SD=35.97) than the low-schizotypy group (M=11.75, SD=10.58) on the EASE scale ($t(36.10)=7.30$, $p<0.01$). There were nine symptoms which were at least mildly present in at least 50% of the high-schizotypy group.

3.3. Paper 3: Volitional and Visually-guided Saccades in Non-clinical Schizotypical Populations

Saccadic eye movements are known to be disturbed in schizophrenia. Fast visually-guided saccades are unimpaired, but slower volitional saccades show longer latencies among people with schizophrenia (Reuter & Kathmann, 2004). Schizophrenia patients also make more errors on the antisaccade task, in which participants must look in the opposite direction to which a target appears (Sereno & Holzman, 1995).

There is some evidence that these deficits can be found in non-clinical high-schizotypy people as well as people with schizophrenia. Most studies have found no difference in saccadic latencies on visually-guided saccades between high- and low-schizotypy participants (Aichert et al., 2012; Brenner et al., 2001; O'Driscoll et al., 1998), but high-schizotypy individuals do make more errors on the antisaccade task than controls (Gooding, 1999; Holzman et al., 1995; O'Driscoll et al., 1998).

We aimed to investigate whether non-clinical high-schizotypy individuals showed this same impairment of volitional saccades, particularly by comparing simple volitional saccades to visually-guided saccades, which had not previously been examined empirically in this group. Further, we aimed to investigate whether impairment on saccade tasks was associated with self disorder experiences as measured by the EASE. To this end, we recruited high- and low-schizotypy individuals (see section 2.2) and invited them to take part in an experimental eye tracking session. The experiment included seven different eye movement conditions (see section 2.3.1.3).

The median latency of correct saccades was determined for each subject in the seven conditions. No significant differences were found in latencies between high- and low-schizotypy groups in any condition. However, between-group latencies of antisaccades were in the expected direction and showed medium effect sizes, $t(24)=1.28$, $p=0.21$, $d=0.50$, with high-schizotypy subjects showing a trend for faster latencies ($M=262.92$, $SD=51.68$) than low-schizotypy subjects ($M=285.38$, $SD=36.76$).

In the high-schizotypy group ($N=13$), there was a strong negative correlation between EASE score and latencies for cued visually-guided saccades, $r(11)=-0.66$, $p=0.02$, and for uncued visually-guided saccades, $r(11)=-0.70$, $p=0.01$. Correlations were also found in the high- and low- schizotypy groups combined ($N=26$) for cued visually-guided saccades,

r(24)=-0.51, p=0.01, and uncued visually-guided saccades, r(24)=-0.42, p=0.03. Other correlations between EASE and latencies, or between SPQ and latencies, were not significant.

4. Discussion and future directions

Based on the introduction and the data from the thesis, a discussion of the relevant findings and issues is presented here. A model of the disruption of agency and self in schizophrenia is presented.

4.1. Addressing the research questions

4.1.1. Paper 1: Agency

4.1.1.1. Paradigms for measuring agency

Research question *What paradigms are used for measuring agency? Which aspect of agency does each involve?*

The field of agency research has produced a large number of innovative paradigms for measuring the degree to which a participant feels in control of an action. This research has often focused on patients with schizophrenia, as disrupted sense of agency is demonstrated in schizophrenia symptoms such as delusions of control. This paper examined the various experimental paradigms in use in the field; a brief overview of which is presented in Table 1 (see section 3.1).

4.1.1.2. Agency in schizophrenia

Research question: *How can apparently contradictory empirical findings regarding disorders of agency in schizophrenia be understood?*

Rather disparate results have emerged when investigating experiences of agency among people with schizophrenia. The comparator model, a prominent neurocognitive model of schizophrenia (Blakemore et al., 1998), implies that schizophrenics would show a decreased sense of agency (see section 1.3.2). However, some experiments have found that people with schizophrenia actually show an enhanced or increased sense of agency – that is, that they are more likely to claim ownership over ambiguously-caused events than healthy people. In false feedback paradigms, for example, participants make hand movements but the visual feedback they see is manipulated to appear different. Feedback may be manipulated spatially or temporally, so that the image of their hand that they see is moving at a different angle or speed from their actual movements. People with schizophrenia are more likely to claim the

hand with the distorted feedback as their own that healthy people, showing an enhanced rather than reduced sense of agency (Franck et al., 2001).

Other paradigms have also found enhanced sense of agency in schizophrenia, such as the intentional binding paradigm (Haggard, Clark and Kalogeras, 2002). This implicit measure of agency leverages the temporal binding which healthy participants show between cause and effect, which people with schizophrenia show more strongly. Also relevant are self-recognition paradigms (van den Bos and Jeannerod, 2002), where participants are presented with images of their gloved hands performing a movement next to images of an experimenter's gloved hand performing the same movements, and the subject must indicate which hand is theirs. People with schizophrenia make more errors on this task, demonstrating a willingness to claim agency over actions which were not initiated by them.

The discrepancies between the comparator model and these experimental findings may be explained by examining the weighting of cues used in assessing agency. Both predictions about the outcome of actions (i.e., intentions) and posthoc information about the actual consequences of actions (i.e., sensory feedback) are important in forming the sense of agency. In schizophrenia, predictions about the consequences of actions are inaccurate, and so sensory feedback may be weighted more strongly than intentions in the attribution of agency (Synofzik et al., 2010). Schizophrenic patients rely more on visual information than on prior mental states or intentions to determine agency. This “sensory-driven-ness” can explain why some experimental paradigms find enhanced agency and some reduced: cues for agency are weighted depending upon their reliability, and people with schizophrenia have inaccurate and therefore unreliable predictions about the outcomes of their actions. Therefore in cases where the predicted outcomes of actions are unreliable, posthoc sensory stimuli are weighted more heavily in agency judgements. This leads to enhanced agency in paradigms where posthoc cues imply that the subject is the agent, and reduced agency in paradigms where the posthoc cues do not imply this.

4.1.2. Paper 2: Self disorders

4.1.2.1. Measuring disorders of self empirically

Research question: *Can self disorder symptoms typically found in schizophrenia be measured reliably in non-clinical populations?*

We adapted the phenomenologically-based EASE checklist into a semi-structured

interview for use in non-clinical populations and tested its reliability. The kappa scores for the interview were high, showing good inter-rater reliability. The kappa scores presented are comparable to values found in reliability studies of both schizophrenia (Norgaard & Parnas, 2012) and first-admission psychosis patients (Møller et al., 2011). Good reliability was achieved through formalising the EASE into a semi-structured interview with set questions, extensive interviewer training, and a clearly described rating guide.

The results show that the ratings of the general extent of self disorder symptoms, operationalised by the EASE total score, and on a substantial number of single items representing specific symptoms, achieve almost perfect inter-rater reliability. The inter-rater reliability of more than 90% of single items can be considered substantial according to Landis and Koch's (1977) interpretation of magnitude.

This study demonstrates the feasibility of reliably measuring self disorder symptoms in a non-clinical population. It addresses the lack of such a tool in the current literature, enabling the measurement of such symptoms in empirical studies.

4.1.2.2. Self disorder symptoms in the non-clinical high-schizotypy population

Research question: *Are the self disorder symptoms typically found in schizophrenia also found in the non-clinical high-schizotypy population?*

High-schizotypy participants scored significantly higher in self disorder symptoms than low-schizotypy participants. There were nine items on which at least half of the high-schizotypy group scored at least mildly present. Self disorder symptoms are considered paradigmatic of schizophrenia (Simms, 1991), and empirical studies have found higher rates of such symptoms in schizophrenia patients than other psychiatric patients and non-clinical controls (Moe & Docherty, 2014). Hence the prevalence of self disorder symptoms in this non-clinical population is remarkable, given that none of the participants were diagnosed with schizophrenia or other psychotic disorder. The mean EASE score in the high-schizotypy group of 63.27 is approaching the scores found in patients with clinical schizophrenia spectrum disorders, such as a study of first episode psychosis patients which found a mean EASE score of 73.50 (Nelson et al., 2012). The findings of self disorder symptoms among non-clinical populations as well as patients is in line with evidence for the continuum model of psychosis (van Os et al., 1999).

This methodology has captured data on a specific set of self disorder symptoms in a systematic way. One limitation is regarding the delineation of self disorder symptoms themselves. Self disorder refers to a broad range of experiences, including unusual experiences of cognition, bodily sensations and presence. Hence the EASE checklist is a list of familiar and related experiences rather than an absolutely demarked symptom set. The inclusion or not of any particular symptom is debatable - anxiety, for example, appears in the EASE, but is not unambiguously a symptom relating to the self as such. However, this is a limitation of such checklist-based tools generally. This sample was not large enough to adequately investigate a factor structure, but a larger-scale study could examine whether there is a consistent underlying factor structure of self disorder symptoms.

Further, an association between schizotypy and anomalies of self-experience would be expected, as the two constructs overlap to some extent. The definition of high-schizotypy, which is captured by the SPQ (see section 2.1.1), includes a number of self disorder symptoms, especially in its subscales "ideas of reference", "odd beliefs or magical thinking" (e.g., experience of thought broadcast), and "unusual perceptual experiences" (e.g., mirror-related confusion phenomena). However, it was not previously clear the extent to which self disorder symptoms would be self-reported by non-clinical high-schizotypy people.

Of the nine symptoms which were at least mildly present in at least 50% of the high-schizotypy group, all items were from the two EASE domains "cognition and stream of consciousness" and "self-awareness and presence". Notably, none of the symptoms in question directly refers to defining traits of schizotypy as defined in the SPQ. Three of the symptoms, thought block, thought pressure, and thought interference, belong to the "formal thought disorders" of schizophrenia (Waters & Badcock, 2010), but are not explicit characteristics of schizotypy. These data show that the EASE can be useful to specify the exact nature of such cognitive abnormalities in high-schizotypy populations.

Another symptom with a substantial prevalence in the high-schizotypy group was hyperreflectivity. Hyperre*flect*ivity, or excessive self-monitoring, is a subset of the exaggerated self-consciousness of hyperre*flex*ivity from the Ipseity-Hyperreflexivity Model (IHM) (Parnas, Sass & Zahavi, 2008) (see section 1.2.1.2, and see Sass et al., 2013 for discussion of the relation between hyperreflexivity and hyperreflectivity). Hyperreflexivity describes the experience of excessively attending to and analysing the normal processes of the body and mind, and has also not been considered a symptom of schizotypy so far. Its

substantial prevalence in the high-schizotypy group is evidence of anomalous self-experience that goes beyond the defining traits of the schizotypy concept and resembles phenomena observed in patients with schizophrenia.

4.1.3. Paper 3: Eye tracking

4.1.3.1. Saccadic eye movements in high-schizotypy individuals

Research question: *Do high-schizotypy people show the same pattern of normal or enhanced visually-guided saccades and impaired volitional saccades as schizophrenic people?*

This pilot study sought to investigate the relationship between two psychological factors (schizotypy and self disorders) and two types of saccadic eye movement (volitional and visually-guided). It is established in the literature that people with schizophrenia have unimpaired visually-guided saccades but impaired volitional saccades (Reuter & Kathmann, 2004), suggesting that there is not a deficit in reaction time to stimuli, in muscular responses, or in the focusing or repositioning of the eye. The slower volitional saccades suggest that it is the generation and/or execution of a willed action that is impaired in schizophrenia. This study investigated whether this pattern of performance would hold for non-clinical high-schizotypy people.

The varying types of saccadic eye movement we investigated represent different levels of volitional or agentic experience. A visually-guided saccade is a stimulus-driven, somewhat automatic reaction to a change in environment, and can thus be understood as primarily reflexive. A simple volitional saccade is self-initiated and agentic, and so is best understood as volitional. The antisaccade task requires the inhibition of a reflexive movement by a volitional one.

No significant differences in latencies of either visually-guided or volitional saccades between high- and low-schizotypy groups were found, which is in line with previous findings in schizotypical populations (Gooding, 1999; Klein et al., 2000). This study expanded upon these results by comparing simple volitional saccade and visually-guided saccade conditions, which had not previously been investigated in schizotypical people. These simple volitional saccades were also found to be unimpaired in schizotypical people, unlike people with schizophrenia who are typically impaired on this task (Reuter & Kathmann, 2004).

4.1.3.2. Disturbed eye movements and self disorders

Research question: *If unusual eye movements are found among high-schizotypy individuals, are these deviances associated with self disorder experiences?*

A strong negative correlation between latencies for visually-guided saccades and self disorder scores was found. This shows that people with high levels of self disorders respond faster to changes in the visual environment than people without self disorders, which may indicate that they are more receptive to or influenced by events in the outside world. This relationship between self disorder symptoms and anomalies of agency will be considered in the following section (4.2).

4.2. Model of disruptions of self and agency in schizophrenia

The findings previously discussed may be best understood by considering the roles and limitations of two models of schizophrenia: the comparator model (CM) (Blakemore et al., 1998) and the ipseity-hyperreflexivity model (IHM) (Parnas, Sass & Zahavi, 2008). The CM is a neurocognitive account of sensorimotor control, which purports to explain the sense of agency and its disruption in schizophrenia. The IHM is a phenomenologically-based model of the disturbance of self in schizophrenia. These two models are brought together by this thesis in general, and the concept of stimulus-driven-ness in particular.

The theoretical paper of this thesis (paper 1) describes agency as arising from the integration of both predictions about the consequences of an action (internally generated, prior to action) and sensory feedback after the action (external, posthoc). The CM posits that it is the comparison of these predicted and actual sensory feedback cues that results in sense of agency. However, this account does not adequately explain some experimental findings in schizophrenia, such as the enhanced sense of agency over spatially-distorted movements compared to controls (Franck et al., 2001). Following the multifactorial weighting conception (Synofzik, 2008), this paper proposed that such discrepancies may be explained by multiple agency cues which are weighted based on their reliability. These cues include but are not limited to the comparison of predicted to actual sensory consequences. Other cues may be integrated in the case of ambiguity – for example, if visual and non-visual sensory feedback are contradictory, then each cue is weighted in the degree to which it contributes to the sense of agency. In schizophrenia, internal cue information is more ambiguous and so less reliable,

so visual information (or other posthoc sensory feedback) is weighted more strongly in the attribution of agency.

The IHM posits that central to the experience of self disorders in schizophrenia are two aspects: hyperreflexivity, or excessive self-awareness, and disturbance in ipseity, i.e. the sense of mine-ness which is implicit in all our actions. Given the nature of the schizophrenia spectrum, it would be expected that such experiences may also be found in people high in schizotypy. The self disorder study (paper 2) was a demonstration that such phenomenological models can be operationalised empirically. It was also an investigation of the prevalence of self disorder symptoms among this non-clinical group. It found evidence of a high prevalence of a number of self disorder symptoms among high-schizotypy people, including hyperreflectivity, a subset of hyperreflexivity.

The eye tracking study presented here (paper 3) demonstrates a link between self disorder symptoms and faster reaction times to changes in the visual field. The negative correlation between self disorder score and latencies for visually-guided saccades is evidence supporting a greater weighting and increased prominence of external cues over internal mental states in schizophrenia spectrum conditions. This is the first time that a link between self disorders and performance on eye movement tasks has been demonstrated in the literature, and from this a model of schizophrenia spectrum conditions can be constructed (see Figure 2).

Figure 2 presents a model of disorders of self and agency in schizophrenia, combining the IHM and the CM with the concept of stimulus-driven-ness. The experience of self disorder symptoms in the IHM leads to a dissolution of the boundary between self and world, which is in turn leads to changes in the world having a greater effect on cognition. This prominence of external events in turn promotes and maintains self disorder symptoms through abnormalities of experience such as aberrant salience. This same stimulus-driven-ness effects the CM, as sensory feedback cues are more reliable than predictive cues and hence are weighted more heavily.

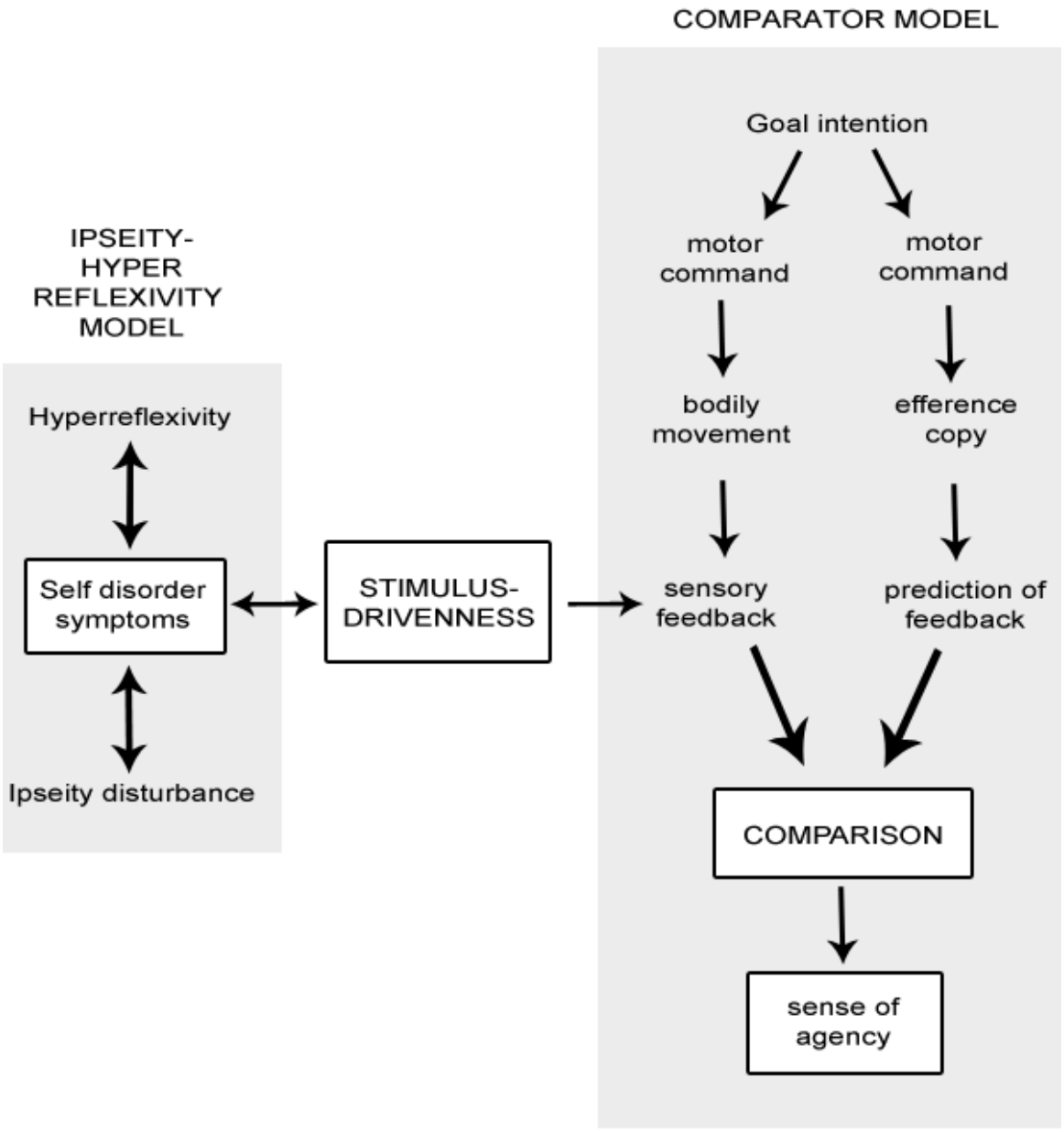

Figure 2: Depiction of the relationship between the Ipseity-Hyperreflexivity Model and the Comparator Model in schizophrenia

This model extends the CM in support of the multifactorial weighting model (Synofzik, 2008) by positing that predictions and sensory data are not just compared by a comparator, but added together in some kind of integration process. Moore & Haggard (2008) suggest that this integration process may be Bayesian in nature, weighting prior information against retrospective information based upon its reliability, in order to minimize uncertainty. In schizophrenia, a faulty prediction mechanism means that the prior is weak and unreliable, and so sense of agency relies more heavily upon other cues such as retrospective sensory feedback.

The weighting of information in a Bayesian manner is supported by evidence from computational models (Hindriks et al., 2011), which distinguish assessments of causality (i.e., judgements of agency) from the feeling of doing (i.e., feeling of agency). Truer (2011) attempts to apply a computational model to schizophrenia which differentiate between prior and retrospective ownership states. But this model found that a low predictive component would also lead to low retrospective component and therefore reduced sense of agency. However, this was only true for a low threshold of prediction components: i.e. that very poor prediction implies no self-ownership. Hence there are suggestions that this mechanism may be understood computationally, however the exact nature of the weighting process remains an open question.

This model, whereby due to previous unreliability, internal prediction cues are weighted less than retrospective sensory data cues, can help explain other empirical findings in schizophrenia. For example, people with schizophrenia are more susceptible to the rubber hand illusion (Costantini & Haggard, 2007), in that they experience ownership over the rubber hand faster than healthy controls – the rubber hand appears in the correct visual position relative to the body and so it is accepted as belonging to them. Here proprioceptive cues regarding the actual position of one's limbs are weighted less than visual feedback cues that the rubber hand is in the place of the one's own hand. Patients with schizophrenia are more susceptible to the illusion than controls because their sense of agency is based more upon the visual feedback which suggests that the rubber hand is their own, than upon the internal monitoring of bodily position which suggests that the rubber hand is not their own.

This can also explain experimental findings of reduced agency in schizophrenia, such as the finding that schizophrenic subjects can tickle themselves more effectively than healthy controls (Blakemore et al., 2000). The participants make movements which are then relayed back to them by a machine, and healthy people recognise their own movements and so do not experience them as surprising or ticklish. People with schizophrenia, however, do find the movements ticklish, suggesting that they experience the self-produced movements as other-produced, showing loss of agency over their own movements. That is, patients with schizophrenia find their own-produced actions ticklish because they do not accurately predict their sensory consequences. In healthy subjects, self-produced stimuli are experienced as less intense because they are predicted, and therefore their sensory consequences are attenuated. But in schizophrenia patients, unreliable internal cues preclude this sensory attenuation so that even self-produced actions seem salient and surprising. Other schizophrenia symptoms such

as delusions of control may also be explained, as a patient's own actions could be experienced as other-produced because the sensory consequences of those actions are unexpected. When, in previous situations, information about one's own internal states has proven unreliable, these internal cues will be weighted lower than more robust cues such as visual feedback, which can create a susceptibility to illusions and from there the development of delusions.

Unreliable sensory predictions in schizophrenia thus lead to an over-weighting of sensory information which can be termed “stimulus-driven-ness”, related to both ipseity disturbance and hyperreflexivity of the IHM. Excessive attention to external events encourages a diminution of self and hence a loss of the “mineness” of experience (loss of ipseity). This insecurity in existential self leads to excessive monitoring of bodily sensations and mental experiences (hyperreflexivity) in an attempt to protect the self from the intrusion of the outside world. This conception is supported by the work of Hauser et al. (2011), who found that loss of ego boundaries highly correlated with ability to improve performance on agency attribution tasks. The authors propose that this unusual performance improvement is due to an over-reliance on external stimuli to make judgements – because people with unclear distinction between self and other rely more on sensory information than prior intentions to identify the agent of an action. This concords with the model presented above; with external stimuli being more reliable to people with schizophrenia and therefore weighted more in assessing agency.

The hyperreflexivity and loss of ipseity of the IHM may be conceived as a disturbance in both agency and self; exaggerated self-consciousness leading to insecurity over both one's actions and one's capacity to perform actions. We found a connection between self disorder symptoms and reacting faster to changes in the external world, supporting this view. Disruptions of self and agency are intertwined: the feeling of being a unified self and the feeling of controlling your body and its actions are mutually supportive. Internal states become unreliable when one lacks a firm experience of self; it is this instability of self which may give rise to the many disparate symptoms of schizophrenia.

4.3. Limitations and implications for future research

Some limitations of the studies and the model must be considered. Firstly, a large number of participants had to be excluded from the eye tracking study due to technical problems, so the remaining 13 versus 13 groups are relatively small. Larger sample sizes would be advantageous in order to detect small effects, and also to examine underlying factor

structures.

As the studies looked only at non-clinical populations, it would also be beneficial to investigate whether the same levels of self disorder symptoms and pattern of eye movement performance holds in other schizophrenia spectrum conditions, such as schizotypal personality disorder or schizoid personality disorder. Examining these populations may elucidate whether these symptoms are found in all schizophrenia spectrum disorders, which would indicate a shared underlying deficit.

The proposed model could be tested empirically in a number of ways, such as investigating attributions of causation among schizophrenia spectrum patients. There is evidence that such patients have unusual perceptions of causation (Jolley et al., 1999), which may be influencing their judgements of agency. The hypothesis would be that schizophrenia patients make judgements of causality based more on information in the external world than on beliefs about the intentions of agents.

Future studies could use other empirical measures of agency to correlate with self disorders in clinical and non-clinical populations. The unusual performance in self recognition paradigms, false feedback tasks and intentional binding paradigms which has been observed in schizophrenia patients may also be found in non-clinical populations who are high in self disorder symptoms. The benefit of this approach is that it allows for the investigation of relations between specific symptoms of schizophrenia and certain cognitive deficits. As schizophrenia is a heterogeneous disorder, two patients with the same diagnosis may show entirely different symptoms, and it is thus hard to make general claims about the disorder. By focusing specifically on self disorder symptoms, the relation between this specific deficit and other cognitive anomalies can be investigated.

4.4. Conclusion

In conclusion, this thesis first considered the inconsistencies between theoretical models and empirical evidence regarding the experience of agency in schizophrenia. It presented a new method of reliably measuring self disorders in non-clinical populations, demonstrating that it is a useful tool for the investigation of specific symptoms in the schizophrenia spectrum. For the first time, a link was made between self disorder symptoms and performance on eye movement tasks, which was made possible by the novel adaptation of phenomenological concepts into behavioural paradigms.

These findings concord with theoretical conceptions of schizophrenia and have been

incorporated into a model combing the neurocognitively-based comparator model and the phenomenologically-based ipseity-hyperreflexivity model. The connection of disorders of self and disorders of agency is a step towards a more complete understanding of cognitive dysfunctions in the schizophrenia spectrum. It is also a demonstration of the possibility of integrating insights and models from different fields in order to understand complex clinical phenomena, and of the advantages of an interdisciplinary approach.

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6. Supplements

6.1. Paper 1: Experimental methods of measuring agency: Conceptual aspects and implications for psychopathology research

Authors: Georgina Torbet [1,2], Benedikt Reuter[2], Norbert Kathmann[2]
Author affiliations: [1]Berlin School of Mind and Brain, [2]Humboldt-Universität zu Berlin

Corresponding author: Georgina Torbet

Corresponding author email: georgina.torbet@gmail.com

Corresponding author address: Berlin School of Mind and Brain, Humboldt-Universität zu Berlin, Luisenstraße 56, 10115 Berlin.

Keywords: agency, schizophrenia, comparator model, motor intentions, action awareness

Abstract:

The field of agency research has produced a wide variety of experimental paradigms and interesting results, especially regarding the experiences of agency in patients with schizophrenia. However, there has yet to emerge a clear consensus regarding the relation between theoretical constructions of agency and the various results produced by experimental observation. This paper will attempt to redress this by describing the various experimental paradigms in use within the field, and considering the conceptual aspect of agency which each measures.

A new theoretical conception of agency is presented which explains the apparently contradictory findings that people with schizophrenia show both enhanced and reduced agency. The model presented is formulated as a weighting of prior mental states (efference copies) and retrospective sensory feedback, based on the reliability of those inputs. When predictions are inaccurate, people with schizophrenia rely more heavily on post-hoc sensory feedback to determine judgments of agency. Hence the different experimental findings: paradigms which ask participants to makes judgments of agency may find both under-estimations and over-estimations dependent upon the sensory feedback which is available to the participants.

Outline:

1. Introduction

Agency, the experience of control we have over our movements and actions, is a topic of interest for psychologists, neuroscientists and philosophers. Helmholtz (1866) first raised the question: when we see motion, how do we know that it is our eyes moving across the world, and not the world moving in front of our eyes? How do we distinguish self-produced movements from movements of the outside world? We have a feeling of control over our movements, which seems natural and invisible to us in everyday life. However, certain mental disorders, notably schizophrenia, show symptoms which have been described in terms of disorders of agency, suggesting that a disruption in this experience of control may lead to various cognitive and social problems (Kircher & Leube, 2003).

It is also of interest to examine the experience of agency in healthy subjects, to see in what situations and to what degree people consider themselves to be the agent of actions. The neural basis of agency has been investigated extensively in recent years, but as yet there is no consensus regarding which brain structures or networks are responsible for the experience of being an agent (see Sperduti, 2011 for a review). This paper will focus on behavioural measures of agency, and the results reported will be behavioural. These paradigms may be utilised in a neuroimaging context, but a review of neural findings is beyond the scope of this paper.

1.1. A note on definitions

The term "agency" can be used to denote experiences ranging from control over motor movements (e.g. moving a finger) to making decisions which affect the outcome of one's life (e.g. deciding to become a scientist). Different fields use the term in vastly different ways, which has lead to some confusion when attempting to broach interdisciplinary work on the topic. This paper will focus on what could be termed “low-level” agency, referring to simple voluntary motor actions. An assumption, not considered here but open to future investigation, is that these low-level experiences of agency build together over time to create an experience of higher-level agency such as making plans for the future.

1.2. Sense of Ownership / Sense of Agency

One important distinction to be made is between the sense of agency and the sense of ownership. Sense of ownership refers to a feeling that one's body (and, debatably, one's thoughts too) belong to you; that you are the owner of them. We can experience ownership without agency, for example in a reflex action – when we touch a hot stove and our hand jerks away, we did not consciously choose to make that movement, yet it still feels as if our hand is the thing which is moving. Breakdowns in the sense of ownership can be found in some pathologies, such as anosognosia for hemiplegia or alien/anarchic hand syndrome. Gallagher (2000) describes the difference as such: the sense of agency is the sense that I am causing or generating a movement, while the sense of ownership is the sense that I am the one who is undergoing the experience. This paper will focus primarily on the aspect of sense of agency.

1.3. Feeling of agency / Judgment of agency

A further important distinction within the concept of sense of agency is between feeling of agency and judgment of agency. The feeling of agency refers to a pre-reflective feeling of acting, while judgment of agency refers to deciding that an action was yours after the fact (see Gallagher, 2000). The sense of agency is reliant upon both agentive experiences (i.e. experiences of feeling of agency), and also the mechanisms responsible for action production (i.e. comparator systems; see section 2.1.2). An important difference between these two concepts is that the feeling of agency involves generating an action through the creation of an efference copy which is private to the subject. A judgment of agency, however, is based on comparing the intentional goal (that is, some kind of theory of mind) to the current state of the environment (which is not private, and may be shared with other observers) (Daprati et al., 1997).

1.4 The debate over mental causation

The debate within philosophy over mental causation focuses on how it is possible for a mental state (such as intention or desire) to cause a physical effect (such as a bodily movement). Given that mental states are not physical, how is it possible that they have physical effects? It feels to me as if my desire caused my behaviour - that is, I have the experience of conscious will causing action - but in fact it is difficult to explain how this could be the case given our current knowledge of mind and brain. This has lead some thinkers to reject the concept of mental states as causal and describe the experience of conscious will as an illusion (Wegner, 2004).

The relation to sense of agency is this: under a causal account, to experience one's movements as voluntary actions is to experience them as being caused by one's mental states (Bayne, 2008). This highlights the importance of mental states to accounts of sense of agency and the relevance of empirical findings to the philosophical debate.

2. Disturbances of agency in mental disorders

Although sense of agency is so fundamental to our experience that it is hard to imagine life

without it, disturbance or disruption of the sense of agency can be observed in some mental disorders. In motor disorders such as Parkinson's disease, patients cannot control the movement of parts of their bodies (Morris, 2002). In obsessive-compulsive disorder, patients' flow of consciousness may be disrupted by obtrusive or reoccurring thoughts, such a reoccurring thought that "I could be responsible for a car crash" (Salkovskis, 1995). However, it is debatable the degree to which any person, whether healthy or disordered, has control or agency over their thinking (Campbell, 2002).

2.1. Specific example: agency in schizophrenia

Of particular interest to this review is patients with schizophrenia, as they experience a range of symptoms related to disturbed agency (Gallagher, 2007) and report a profound change in their phenomenological experience of action (Sass and Parnas, 2007). Some patients experience delusions of control, where they believe that another person or entity is controlling their bodies. Others report a loss of inherent “mineness” of their actions (Sass & Parnas 2003).

2.1.2. The Comparator Model and its predictions

The most popular theoretical model of schizophrenia, the comparator model, posits a mechanism through which the sense of agency may be reduced or impaired in schizophrenia (Blakemore et al., 1998, Blakemore et al., 2000). It states that before an action is made, the motor system generates a prediction of the likely sensory consequences of that action, also known as efference copy. Once the action has been made, the efference copy is compared to the actual sensory feedback, and if they match then the subject feels themselves to be the agent of the action. In schizophrenia, the efference copy is supposed to be inaccurate, leading to sensory mismatch, and therefore to a loss of the feeling of agency (Blakemore, Wolpert and Frith, 2002). Symptoms such as delusions of control may occur as the actual sensory input does not match the prediction, so one's thoughts and actions may appear to be externally generated. There is a correlation between the severity of delusions of control and less precise predictions of sensory consequences of action (Synofziket al., 2010). These patients are more reliant upon external and post-hoc cues when assigning agency to themselves or others (Frith, 2012).

This model predicts that in an experimental setting, people with schizophrenia would typically show a lessened sense of agency and this has been found using some paradigms (see Frith, 2012). In other paradigms, however, people with schizophrenia show an enhanced or increased sense of agency (e.g. Franck et. al, 2001; Voss, 2010). To understand these apparently contradictory experimental findings, the concept of agency must be more carefully defined, and the paradigms must be considered in terms of the aspect of agency which they measure (see Synofzik et al., 2008).

2.1.3. The Free Energy Principle and hierarchical processing models

The concept of predictions as inherently important to cognitive processing is reiterated in Friston's (2010) free energy account. This approach states that the mind/brain is optimised so as to process large amounts of information in an efficient manner by making predictions about the likely consequences of the actions of oneself or others. Attention and resources are dedicated only to those things which are incongruous with predictions. On a neural level, this efficiency is implemented by predictive coding mechanisms (Firston & Kiebel, 2009). This predictive coding is effected in both directions by top-down probabilistic models - so a person's knowledge and experience of the world is used to make predictions about likely outcomes. When something unexpected happens, it is attended to because of its incongruity. Clark (2012) applies this model to perception, cognition and action, and argues that these three concepts are inherently intertwined without clear boundaries between them. This is important for understanding the nature of the experience of action: that the feeling of agency may not be dissociable from the perceptual and cognitive processes which support it.

This account can also be applied to schizophrenia, particularly in examining the sensory effects of self-produced actions. Brown et al. (2013), for example, discuss the relation between the experience of agency and sensory attenuation. Sensory attenuation refers to the finding that the sensory consequences of self-produced actions are experienced as less intense than the sensory consequence of other-produced actions. When a person makes an action which produces a sound, for example, they experience that sound as being less loud than if it were produced by another person (Weiss, Herwig & Schütz-Bosbach, 2011). However, this sensory attenuation is known to be reduced in schizophrenia (Blakemore et al., 2000), and within this group, poor prediction of the sensory consequences of one's own actions is correlated with the strength of delusions of influence (Lindner, 2005). This reduction in

sensory attenuation can give rise to false or delusional beliefs about agency (Brown et al., 2013), making it less clear whether an action was produced by oneself or another. This may relate to the self-disorder symptoms of schizophrenia, as the distinction between self-produced and other-produced actions is essential for the pre-reflexive feeling of unified selfhood (Limanowski & Blankenburg, 2013).

2.1.4. Apparently contradictory findings

The comparator model predicts reduced sense of agency in schizophrenia, however some experiments have found that sense of agency is enhanced, such as the false feedback tasks of Franck et al. (2001). An image of a computer-generated hand is imposed over the subject's hand using mirrors, and movements are altered spatially or temporally and the subject must identify whether the movement seen is their own. Schizophrenic patients tend to identify these alien hands as belonging to them more than healthy controls. Here patients are claiming more agency than controls, showing an the distortions of agency in schizophrenia are not only in the direction of reduced or too little agency.

Further, the comparator model may explain the feeling of agency, but is not sufficient to explain the judgment of agency (Synofzik et al., 2008). A problem with the model is regarding the threshold at which a difference between predicted and actual feedback indicates a mismatch - the threshold cannot be very low as subjects still identify movements as their own when manipulated spatially (Franck et al., 2001) and correctly identify their voices when the pitch is changed (Cahill, 1996). At what point is the distinction between self-produced and other-produced actions drawn? Suggestion of a second, higher-order comparator leads to infinite regress. In order to determine what the effects of a movement are, the comparator system must already represent which movements are self-caused.

Although the comparator model is often invoked to explain first rank symptoms including delusions of control and auditory hallucinations, there remain several inconsistencies between the theory and empirical findings. One would expect that a failure in the forward model would cause major deficits in motor control, but this is not generally impaired in schizophrenia (Frith, 2012). Another issue is that mere failure of prediction is not sufficient to explain how delusions are generated (Davies, 2001). Also, the model might explain why a patient believes that they are not in control of their actions, but it does not explain why they attribute agency to another person (nor why they believe any particular specific person to be responsible)

(Waters & Badcock, 2010).

As yet, there is no consensus regarding how agency can be measured empirically, and how these empirical findings can support or challenge the dominant theoretical model. In order to understand the source of these contradictions, we will now examine the experimental paradigms currently used to measure agency, and consider what aspect of agency each of them engages with.

3. Experimental paradigms

A number of different paradigms to investigate agency are available in the literature, but no one is accepted as standard. For the sake of future research, it would be beneficial to assess these paradigms and discuss the aspects of agency which they measure. This may also help to explain some apparently contradictory findings in the literature - for example, some paradigms have found enhanced sense of agency in schizophrenia and some have found reduced sense of agency Five types of paradigm will be discussed below, and the aspects of agency that each measures will be considered.

False feedback paradigms:

One of the earliest experimental methods of measuring agency was the false feedback method developed by Nielsen (1963) used on healthy subjects. This paradigm involved the subject and the experimenter placing their hand into a box and the subject being asked to draw a straight line on a piece of paper. The box was designed such that the subject could see their hand, but a mirror placed inside could be used by the experimenter to make it appear as if the experimenter's hand had taken the place of the subject's. Thus the experimenter could allow the subject to see their own hand drawing a straight line on some trials, but make it appear as if the subject's hand was moving in another direction on other trials. After the experiment, subjects were asked for a phenomenological description of their experience, to see how they reacted to what appeared to be their hand moving without their control. The majority of participants (18 out of 20) continued to perceive the alien hand as belonging to them even when it moved differently from their hand's real movement. The authors also took note of aspects of the phenomenal experience including experiences of non-volition and perceptual abnormalities.

The findings were that participants would automatically compensate for the (false) movements that they saw, even without being consciously aware that they were doing so – if, for example, their virtual hand appeared to be curving to the right, then their actual actual hand would make a movement which curved to the left. They also found that people tended to maintain that the hand was their own, even in the face of bizarre movements. They did not experience a breakdown of personal identity. When subjects described a conflict between what they felt their hand was doing and what they saw their hand doing, they tended to prioritize the visual information.

This method allows an experimenter to induce an experience where it seems to the subject that their hand is moving in a way they did not intend. Thus it is an experimentally-induced experience of disruption of agency. The study by Nielsen focused on the explanations that different groups of subjects would give for this apparent disruption of agentic experience. It is useful to investigate the strategies used in order to account for disruption of agency, but this study makes no claims regarding the causes of these disruptions.

This methodology was used again by Sørensen (2005) to investigate body ownership among bulimic women. Participants were exposed to the alien hand and the descriptions they gave of their experience were analyzed for content and classified into internal or external attribution of causation. He found that bulimic women compared to both men and non-bulimic women experienced a significantly lesser degree of sense of agency and were more likely to identify external forces as causing their movements.

A different form of "false feedback" was used in the paradigm of Fourneret and Jeannerod (1998), following the work of Malenka et al. (1982) which found that healthy people are able to recognize and correct errors in their movements without exteroceptive signals, but people with schizophrenia are less able to do so. Fourneret and Jeannerod asked participants to make movements with a stylus, drawing a straight line. The appearance of the line was modified (originally using mirrors, and in later versions with computer software), so that the line which appeared was spatially deviant. After each trial, participants were shown images a variety of lines at varying spatial deviations and asked which line corresponded to their movements. They found that most subjects (9 out of N=13) misperceived the direction of their hand movement (thinking that they had moved their hand in the direction of the spatial deviation). The authors concluded that normal subjects had poor conscious monitoring of their motor actions and are not necessarily aware of the signals generated by their own movements.

Computerised false feedback paradigms:

Variations on the false feedback method have developed as technological progression has made such false feedback easier to give. Franck et al. (2001) used a methodology in which subjects were invited to hold a joystick and instructed to make various movements with it. A computer-generated virtual hand was imposed on top of their own hand through the use of mirrors. The visual feedback of the virtual hand at first matched the subject's own hand, but in later trials spatial and temporal discrepancies were introduced. Subjects were asked after each trial whether the movement they had seen the virtual hand perform was their own or not. The authors compared healthy controls (N=29) to people with schizophrenia both with delusions of control (N=6) and without (N=18). They found that both healthy and schizophrenic subjects would accept a movement as their own if it was less than 150ms temporally distorted or 15° spatially distorted, suggesting a limit to the accuracy of perception of one's own movements. Patients with and without delusions of control were less accurate than control when temporal distortion was at 300 ms or more, in that they continued to claim ownership over the movement even when it was delayed.

Surprisingly, patients without delusions of control did not generally differ from the control group in their responses when movements were distorted spatially. Patients with delusions of control gave more positive responses regarding ownership than the other schizophrenic group or the control group, in both spatial and temporal conditions. This method is effective for measuring the degree of spatial or temporal change in feedback under which a subject still recognizes a movement as their own. Overall, the study found a high willingness of subjects to accept movements as their own, even when they were spatially or temporally distorted, particularly in the group of schizophrenics with delusions of control.

One issue is that this methodology asks subjects to make a post-hoc judgment about their ownership over the movement they have seen. Subjects were asked whether the movement "exactly correspond[ed]" with the movements they had made. It could be that results were confounded by individual differences in attention, eye sight, or in interpretations of how close correspondence must be to be considered exact. Also, the question "Did the movement you saw on the screen exactly correspond to that you have made with your hand?" may be unclear to participants, as it could be asking for either a self-versus-other judgment or an assessment of the feeling of agency. Further, the group of patients with delusions of control was small

(N=6) so findings may not be generalisable.

A similar paradigm was used by Nahab et al (2011) in an experiment which included an MRI component, though here we will focus on the behavioural task. Healthy subjects were asked to perform sequential hand movements which were recorded with a special glove, and they received real-time visual feedback from a virtual simulated hand. The simulated hand's movements were varied by the computer so that the subject had between 100% and 0% control over the movements of the simulation. After each block, subjects were asked to indicate the level of control they felt over the movements on a scale of 0 – 100. They found that subjects were fairly accurate in their estimates of the degree to which they had control, finding the estimates to be within 15% of the actual control level for each condition. Interestingly, when the subject's level of control was over 50%, they tended to overestimate this, while when the actual level of control was below 50%, they tended to underestimate. The authors thus argue that the sense of agency is not experienced as a binary perception (i.e. either present or absent), but rather that intermediate levels of agency may be experienced.

Another variation on the "false feedback" paradigm was created by Asai and Tanno (2007), whereby control and schizotypical subjects controlled a cursor on a computer screen using a mouse. The movements on screen were adjusted either spatially or temporally, and subjects were asked whether the movement they saw on screen was caused by themselves or by the experimenter. Interestingly, in this paradigm both perception of bias and sense of self-agency were addressed through separate verbal responses. In separate blocks, participants were asked whether they thought that a spatial or temporal delay had occurred (to assess perception of bias) or whether they thought that they had moved the cursor on their own (to assess sense of self-agency).

The differentiation of the two tasks is important as a way to dissociative perception of an action from sense of agency over that action. This is particularly relevant when working with schizotypical people, as schizotypy has been linked to unusual judgments of causation (Jolley et al., 1999). The authors found that the high-schizotypical people showed the same judgments of bias as the low-schizotypical group, but they experienced a weaker sense of self-agency on spatially-distorted trials. The authors acknowledge the small number of participants (N=20) means that the results should be considered preliminary.

A further variation was created by Hauser et al. (2011), in which subjects heard a computer-generated series of drum sounds and had to reproduce those sounds on a drum pad. Whilst

they were drumming, the sounds that subjects heard were either faithful replications of their input, or they were reproductions of the computer-generated sounds (which were either identical to the original series, or sped up or slowed down). They were then asked “who controlled the series of sounds?”and could respond with either “I did” or “the computer did”. They tested both schizophrenic and prodromal patients on this task as well as healthy controls. They found that both groups of patients showed an exaggerated self-attribution bias, that is, that they were more likely to claim agency over the sounds even if they were actually computer-generated. There was no significant difference between schizophrenic and prodromal patients in this bias, but it was correlated with the level of patients' ego-pathology. The authors also found that patients' performance on the task was improved when the discrepancies between actual movement and received feedback were larger, unlike healthy controls whose performance did not benefit from these additional cues. They suggest that patients weight these external cues more heavily than their internal sensorimotor signals, and, in cases of ambiguity regarding the accuracy of internal predictions, rely more upon additional perceptual cues for agency judgments.

Agency judgment with priming paradigm:

Aarts et al. (2005) discuss the importance of time perception in agency: that is, how we often make a judgment of agency based on the temporal propinquity of two events. They relate this to priming, in that a person's prior expectations about their intended action will influence the likelihood of them claiming authorship of an action. They investigated whether priming the effects of an action enhances the feeling of agency (and/or authorship) over that action. This is particularly relevant to the philosophical discussion of the role of intentions in apparent mental causation (see section 1.4).

The experimental paradigm involved a wheel of fortune games, in which participants had to move a grey square around a grid of white squares using a keyboard (Aarts et al., 2005). At the same time, another grey square was moved in the opposite direction by the computer. Participants had to stop the movement by pressing a different key, at which point a black square would appear. They had to judge whether the location of the black square was based on the current position of their grey square, or of the computer's grey square. This task allows some ambiguity about who was the cause of the final result, the participant or the computer, although the participant remains the generator of their actions.

On some trials, the location of the black square was primed subliminally before the participant pressed the button. The finding was that in trials which had been primed in this way, participants were more likely to attribute causation to themselves. This demonstrates that priming of effect information can influence the agency judgments of participants.

Another measure of agency which included priming was performed by Gentsch et al., 2012. This involved presenting participants with two buttons: a left and a right key, each of which triggered a visual effect of a blue or a red square. Blocks were either high- or low-contingency, such that in high-contingency conditions each button was associated with a particular colour which appeared in 75% of trials (e.g. if the right key was associated with the blue square, then pressing the right key would result in a blue square on 75% of trials). In the other 25% of trials the other colour appeared. In low-contingency conditions, both keys were equally likely to produce either colour (i.e. either button produced each colour on 50% of trials). This task meant that factors such as shape, timing and location were kept constant between conditions. Priming took place before the button press, where a prime word was presented which was either the same or a different colour from the effect. Participants were asked to judge on a scale of 1 to 100 how strong they felt the causal relation between action and effect to be for each block.

In addition, two control tasks were included: an effect-only task in which the participant observed the button selection and outcome without pressing anything themselves, and a motor-only task in which participants pressed a button but no effect followed.

This paradigm was used to gather data in both healthy subjects and OCD patients. Healthy subjects gave higher agency ratings in congruously-primed conditions than incongruously-primed conditions in the high-contingency conditions (but not the low-contingency conditions). OCD patients, however, gave agency ratings which were not affected by the congruency of the prime in both high- and low- contingency conditions. This demonstrated the differing weighting of components of agency between healthy and disordered individuals, as well as the relevance of prior information about causation (in the form of priming) on judgments of agency.

A further experiment was performed by Damen, Baaren and Dijksterhuis (2014), who tested healthy subjects on a judgment of agency task which included priming. Subjects were presented with left and right buttons which generated tones, and asked to press a button of their choice. They were told that the tones may be produced by themselves or by the

computer, but in fact the subjects always produced the tones themselves. They were asked at the end of each trial to indicate on a 1-100 scale the degree to which they felt they had caused the tone to occur. In some trials, before pressing a button, they were primed with a subliminal or supraliminal presentation of the word "left" or "right" - and this instruction could be either compatible with their button press or incompatible. The authors found that subliminal (i.e. non-conscious) incompatible primes lower agency ratings, but supraliminal (i.e. conscious) compatible primes also lowered agency ratings. This suggests that compatible subliminal action primes may be used in action selection, leading to a strong sense of agency. However, the conscious awareness that one is following an instruction would reduce the sense of agency.

One issue with this study, however, is that the tones were always produced by the participants, never another person or the computer. It is unclear how this may have effected subjects' judgments of agency, as subjects may have found it implausible that the computer could be producing the tones.

Intentional Binding paradigms:

Another approach to measuring agency is through asking subjects to report on the perceived timing of their own actions. Haggard, Clark and Kalogeras (2002) investigated the perceived time that elapsed between a voluntary action and its effects. Subjects watched a clock and judged the onset time of an event. There were four conditions, with a different event in each one - a voluntary key press, a TMS-induced pulse which caused their finger to twitch, a sham TMS condition, and an auditory tone. A tone was sounded 250ms after the event, and subjects estimated the time at which the event occurred. The finding was that, in the voluntary key press condition, the awareness of the action was shifted later, towards the tone, while awareness of the tone was shifted earlier, towards the key press. Involuntary, TMS-produced actions showed the opposite effect, where the action was perceived as taking place earlier in time, and the effect later.

The authors explain these effects as a binding; whereby awareness of voluntary action and perception of the action's sensory consequences are linked. The temporal interval between the two is underestimated, so it seems that they occurred closer together than they actually did. However, this binding effect is not found in actions which were not voluntary, such as a TMS-induced movement.

A variation of the intentional binding paradigm which investigated the role of prior and post-hoc information on feeling of agency was described by Voss et al (2010). The experiment was conducted as described above, but with a variation in the probability that the participant would hear the tone which comes after the button press. So on some trials the tone sounded 50% of the time, and on others 75% of the time. This allowed the authors to investigate the role of intentions which were prior to the action (i.e. the intention to press the button) and of sensory information which comes after the action (i.e. hearing the tone) in the feeling of agency. The key condition investigated whether binding would still happen when the tone was expected but not heard (i.e. the trials in the 75% probability block which did *not* include the tone).

The Voss et al. study confirmed findings that subjects with schizophrenia were more likely than controls to show binding based on incorrect feedback – that is, people with schizophrenia showed an excessive sense of agency based on post-hoc sensory information.

One issue with the Intentional Binding paradigm is that, being an implicit measure, it is not known for sure what aspect of agency it measures. Some have argued that the paradigm is better understood as a measure of causation than of feeling of agency (Buehner, 2012) – that is, that the change in temporal estimation seen is induced by the causal link between action and consequence, rather than agentic experience. Empirical investigation found the binding effect even in cases where the relevant action was performed by a machine, rather than the subject themselves. This can be interpreted as demonstration of intentional binding-type effects even in case where no intention was present. The author suggests that the effect would be better referred to as a specific type of causal binding, as intention may not be the driving force of the change in temporal estimations.

This would mean that intentional binding should not be considered a true measure of feeling of agency, but rather a property of the observation of causation generally. However, a recent study by Moore et al. (2013) has found somewhat contradictory results. Subjects watched videos of a confederate pushing a button and were then asked to estimate the time which elapsed between button press and tone. The four conditions were: two causal conditions in which the tone was heard, one of which they were told was the confederate pushing the button when they chose, and the other of which was the same video but described as the confederate's finger being moved by a motor; and two non-causal conditions, in which they saw the videos but heard no tones.

This study found that the estimates of time elapsed were significantly different between the intentional and unintentional conditions, even though the videos that the subjects saw were the same. This suggests that the subjects' understanding of the prior intentions and/or mental states of the person shown in the video was relevant to the degree of temporal distortion which they displayed; and thus that the intentional binding effect may after all be based on intentional states. They considered the possibility that these data were affected by reaction times, but when assessed statistically, the relationship between RT and mean interval time estimates was found to not be significant.

Although this study supports the concept of intentional binding as a measure of agent causation, it does demonstrate that the IB effect is found when the participant observes others' actions as well as their own. That is to say, the IB effect is not exclusive to self-generated actions, but is found in other-generated actions too. Thus is it best understood as an implicit measure of agent causation.

Self-recognition paradigms:

An investigation of self-recognition was performed by van den Bos and Jeannerod (2002), examining the roles of both sense of body ownership and sense of actions. Subjects were invited to site at a table opposite an experimenter and lay their hand on the table. The experimenters did the same, and each hand was covered by a glove to minimize morphological differences. Subjects were presented with an image of their own hand and also the experimenter's hand, and then hands performed the same movement, a different movement or no movement at all. Images were presented at various rotations also, so that the hands may be switched by 180° (swapped position with the experimenter) or other degrees. Subjects were then asked to identify which of the hands seen on screen was their own.

Mistaken attribution (believing a hand to be yours when in fact it is not) was more common in the 180° rotation condition, where the experimenter's hand appeared where the subject expected their own hand to be, relative to their body. An anatomically plausible position of the hand seems to be an important cue for determining ownership. However, this effect was nullified when the experimenter's hand performed a different movement from the subject's hand. The findings were that subjects had difficulty in differentiating the experimenter's hand from their own when there was no movement. When both hands executed the same movement, subjects could identify their hand somewhat better. When the hands executed

different movements subjects could easily tell them apart. This suggests that the presence of movements was also a cue for determining ownership, even more importantly than the visual position of the hand.

A pilot study was conducted using this paradigm with schizophrenic patients, and found that patients with hallucinations and those with delusions of control showed more recognition errors than patients without hallucinations or healthy controls (Jeannerod et al., 2003). The patients made a notably high number of mistakes on trials in which both the experimenter's hand and the subject's hand made the same movement. Important here is the variation in performance within the schizophrenic group; the presence of hallucinations or delusions of control made a significant difference to the subjects' ability to distinguish their own movements from the movements of others.

Blakemore, Frith & Wolpert (1999) came up with a different and inventive method of investigating self-produced actions. A long-standing finding regarding motor awareness is that when a subject produces a tickling motion on themselves, they report it as less tickly than the same motion performed by another person. (Weiskrantz, Elliott & Darlington, 1971). The assumption is that self-produced action generates an efference copy, and therefore the sensory consequences (of tactile stimulation on the skin) is less surprising and less tickly.

In their experiment, subjects experienced a tactile stimulation on the palm of their hand which was either self-produced or externally produced by a robot. They also introduced a temporal delay or trajectory perturbation to the action after it was performed on some trials. Subjects rated self-produced stimulation as significantly less tickly, less intense and less pleasant than externally-produced stimulation. They also found that ratings of ticklishness increased with the delay between movement and stimulation and the degree of perturbation.

In patients with schizophrenia, however, they found that these people did not differ in their ratings of ticklishness between movements produced by themselves and by others (Blakemore et al., 2000). This means that the patients were able to tickle themselves, which demonstrates their predictions of the sensory consequences of their actions was somehow impaired.

An extension of this paradigm was performed by Van Doorn, Hohwy & Symmons (2014), who investigated the effects of the body transfer illusion on the ability to tickle oneself. The body transfer illusion is a manipulation of body image, in which the experimenter, wearing a camera on their head, sits opposite the participant, who wears goggles which relay real-time visual information from the camera. The participant thus experiences actions from the visual

first-person perspective of the experimenter. Whilst in this setup, participants felt tickling sensations on their hand which were generated either by themselves or by the experimenter, and were asked to rate how ticklish each sensation was. Surprisingly, they found that the inability to tickle oneself remained even when the body transfer illusion was in effect. Even when they are receiving visual information from the perspective of another person, subjects still rated self-produced movements as less ticklish than other-produced movements. The authors argue that this supports the account of action as involving suspension of attention to visual feedback so that proprioceptive signals may be prioritised. That is, when a person makes a voluntary action, the interoceptive signals regarding the effects of that action are attenuated, even when contextual cues such as those involved in body image, are manipulated.

Action ownership paradigms:

An experimental paradigm involving agency, priming and motor intention was performed by Wegner and Wheatley (1999). They paired subjects with a confederate and seated them together in front of a screen and a trackball. Various objects were shown on the screen, and the trackball, controlled by both subject and confederate simultaneously, could be used to select an object. Subjects and confederate used the trackball to move a cursor on screen, and they had to stop the cursor on an object of their choice at an indicated time. The subject wore headphones which played music to indicate when they must stop on an object, but the headphones also played a voice speaking the name of various objects. After hearing the name of an object (either 30 seconds, 5 seconds or 1 second before the stop or 1 second after the stop), the confederate would stop the cursor on the image of that object. Participants then rated on a 1 to 100 scale whether they allowed the stop to happen or intended to make the stop. This experiment tested the effect of priming an object, to see if it would make subjects believe that the intention to stop on said object was theirs, even when the action was actually performed by the confederate.

Subjects generally perceived the forced stops as intentional, even when they were not caused by themselves. However, the degree to which they believed this depending upon the other conditions - it was lower when the prime was given 30 seconds before the stop, higher at 5 seconds or 1 second before and lower again at 1 second after. This suggests that there is a particular time period during which intentions are formed, and that introducing priming cues at this time will make the subject more likely to claim agency over an action.

A similar paradigm was used with healthy and schizophrenic patients by Metcalfe et al. (2012) in which subjects had to complete a movement task on a computer in which their inputs were sometimes distorted by random noise. They were asked to judge their degree of agency over the controls as well as the accuracy of their performance. They found that, on trials where inputs were distorted, healthy controls rated judgments of both performance and agency as lower than on non-distorted trials. Patients, however, showed lower judgments of performance on distorted trials but not lower judgments of agency - that is, they knew that they had done the task less well but they still felt the same degree of agency of the movements even though they were distorted. The authors conclude that patients use publicly available external cues when making judgments of agency, and not internal self-relevant cues. In contrast to the Wegner and Wheatley experiment, however, there was no other person present to whom agency could be attributed - rather, the subjects had to decide whether it was them or the computer who had agency. This is relevant as it is possible that assessments of self-vs-other agency could be different when the other in question is a person rather than a computer.

4.1. A proposed solution

Discrepancies between theoretical and empirical models of agency in schizophrenia may be explained by different weighting of information. Agency may arise from the integration of both predictions and sensory experiences. Thus if internal predictions about visual consequences of actions are inaccurate (Synofzik et al., 2010), then visual (or other perceptual) information may be weighted more strongly in attribution of agency. So schizophrenic patients rely more on visual information than on prior mental states or intentions to determine agency. Thus experiments would fine both over- and under-attribution of agency in schizophrenia, depending on the particular task (Voss, 2010 ; Synofzik, 2010). On tasks which provide sensory feedback, people with schizophrenia would put more emphasis on the feedback than on their intentions when assessing their own agency.

This explanation for the discovery of both over- and under-attribution of agency is supported by the findings of Voss et al (2010). By utilising an intentional binding (IB) paradigm, they differentiated the predictive and retrospective components of sense of agency experimentally. IB experiments show that people under-estimate the temporal gap between two actions (e.g. pressing a button and hearing a tone) if they believe that their action has caused the effect. By varying the probability than the tone will be heard, the experimenters differentiated the degree

to which subjects could predict the tone. Here schizophrenic subjects showed very little evidence of predictive components in IB; their experience of agency was driven by sensory experience after the event - i.e. retrospectively. In healthy controls, on the other hand, the probability of hearing a tone greatly affected the IB effects, suggesting that for these people their sense of agency rested mostly upon predictive mechanisms.

Proposed here is a more complex model of agency in schizophrenia: rather than being simply reduced or enhanced, sense of agency relies on two distinct components: predictive and retrospective. Schizophrenic subjects may show abnormal weighting between these two components, which can result in either over- or under-attribution of agency, dependent upon context. In relation to the comparator model, this view states that predictions and sensory data are not just compared, but added together in some kind of integration process. Moore & Haggard (2008) suggest that this integration process may be Bayesian in nature, weighting prior information against retrospective information to minimize uncertainty. For instance, if a prior is weak and unreliable (as it may be in schizophrenia due to the "faulty prediction mechanism" described in the feedforward model), then estimations would rely more heavily upon retrospective information.

The Bayesian network theory is supported by evidence from computational models (Hindriks et al., 2011), which distinguish assessments of causality (i.e. judgments of agency) from the feeling of doing (i.e. feeling of agency). Treur (2011) attempts to apply a computational model to schizophrenia which differentiate between prior and retrospective ownership states. But this model found that a low predictive component would also lead to low retrospective component and therefore reduced sense of agency. However, this was only true for a low threshold of prediction components: i.e. that very poor prediction implies no self-ownership. A Bayesian approach to this prior/retrospective model may have different findings due to the weighting of different states.

Abnormal integration of predictive and retrospective components of agency would explain why schizophrenic subjects are able to make accurate corrections to false feedback without being aware that they are doing so, because the prediction is suppressing the retrospective sensory data. When the differences between movements and feedback are made sufficiently large as to reach conscious awareness, schizophrenic subjects are slow to switch to a conscious strategy as they become heavily reliant upon the retrospective data. It may be that when differences between movements and feedback are small, subjects are experiencing a

prediction-based sense of agency, but when the differences enter consciousness then they must switch to a retrospective-based judgment of agency.

4.2 Putting this into practice: future experiments and topics of interest

This work reinforces the need for carefully planning of experiments regarding agency, and of the interpretation of these experiments. If subjects are asked to indicate the degree to which they felt control over an action, then it must be remembered that this is a judgment of agency, not a report of a first-personal feeling of agency. It is also important to consider the manner in which such a question is phrased: "did you make that happen or did the computer?" is quite a different question than "to what degree did you feel in control of that action?".

Paradigms which are capable of differentiating judgments of agency from the feeling of agency are of particular value when dealing with patients. In healthy people under normal conditions, judgments and feelings of agency are likely to be congruous, and measuring one should reliably correlate with the other. In schizophrenia particularly, however, the exact nature of the disruption of agency is unclear. Identifying the underlying factor in this disruption will require carefully calibrated experiments which can differentiate between different aspects of agency.

Fruitful experiments could involve a combination of implicit measures, which tend to measure the feeling of agency, and explicit measures, which tend to measure judgments of agency. This also has the advantage of reducing experimenter effects, as it is not always clear to the participants what is expected of them. Other sensory modalities are of interest too: how are experiences of agency affected by perception of touch, as opposed to sound or visual feedback? And further, what is the exact distinction between reflexive and volitional actions? Is the experience of agency over very fast actions binary (i.e. "I did that" or "I did not do that") or is it on a continuous scale? What about experiences of agency over different kinds of bodily movements - most experiments use motor movements of the hands, but do the same agentic experience apply to other motor conditions, such as eye movements? All of these avenues may provide insight into the nature of agency, both in healthy subjects and in patients with schizophrenia.

5. Conclusion

The common paradigms used to examine agency in the neurocognitive literature have given some apparently contradictory results, especially in schizophrenia, due to a lack of conceptual clarity over exactly what aspect of agency is being measured. Philosophical concepts of agency as a complex weighting of information from both prior mental states and post-hoc sensory information can help explain these apparent discrepancies.

6. Conflict of interest

The authors have no conflicts of interest to declare.

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6.2. Paper 2: Reliability of measuring self disorders in a non-clinical population

Authors & affliations:

G. Torbet [1,2], D. Schulze[2], A. Fiedler[2], N. Kathmann[2], B. Reuter[2]

[1] Berlin School of Mind and Brain, Berlin, Germany, [2] Humboldt-Universiät zu Berlin, Berlin, Germany

Corresponding author:

Georgina Torbet, Humboldt-Universität zu Berlin, Luisenstraße 56, 10115 Berlin, Tel: +49 1763 9292575, Email: georgina.torbet@gmail.com

Abstract:

Objective: To explore whether anomalies of self-experience occur and can be assessed reliably in a non-clinical sample, and whether the prevalence of these anomalies depends upon the degree of psychometrically defined schizotypy.

Method: Participants with either high (n=30) or low (n=20) schizotypy scores were interviewed using a modified version of the Examination of Anomalous Self-Experience (EASE). The degree to which interviewees experienced self disorder symptoms was rated by the interviewer and an independent rater. Inter-rater reliability was calculated for each item and the average reliability scores for domain scores and the total were calculated.

Results: Most items (=66) showed substantial or perfect agreement (kappa > 0.61), with a few (=6) showing moderate agreement (kappa > 0.41). The average inter-rater reliability score of all items indicated substantial agreement (mean kappa = 0.76).

Conclusion: The assessment showed good levels of reliability when measuring self disorder symptoms among non-clinical populations who were high or low in schizotypy.

Keywords:

Schizophrenia, observer variation, psychometrics.

1. Introduction

Self disorders (or *Ich-Störungen*) are symptoms related to a loss of unity of the self, and are considered paradigmatic of schizophrenia (Estroff, 1989; Sass and Parnas, 2003). Examples of such disorders include feeling as if the boundary between self and world is unclear, difficulty in distinguishing experience from a memory or a dream, or feeling as if the mind does not reside comfortably within the body (Cermolacce, Naudin, & Parnas, 2007).

Although the relevance of self-disorders is well-established in phenomenological literature (e.g. Parnas & Handest, 2003; Sass, 2000; Sims 1991; Moe & Docherty, 2014), there is relatively little knowledge of their biological and psychological underpinnings. This is partly due to the idiosyncratic nature of the putative phenomena, which makes it difficult to operationalise the construct in a reliable and valid way.

The Examination of Anomalous Self-Experience (EASE) (Parnas et al., 2005) aims to assess self-disorder experiences through a clinical interview and a rating on a descriptive-psychopathological checklist of 57 items. All items are rated on a 4-point Likert scale (0=absent, 1=questionably present, 2=present[mild], 4=present[moderate], 5=present[severe]).

The EASE and other approaches to assessing self disorders (e.g. parts of the Bonn Scale for the Assessment of Basic Symptoms, BSABS, Gross, 1989) have been developed for use in clinical settings with patients with schizophrenia or other severe psychotic disorders. Investigation of such patients may be limited by medication and the multitude of different functional impairments found in many patients. Hence, research in anomalies of self-experience may be complemented by the investigation of less severely impaired individuals. Self disorder symptoms have been observed in people who are at high risk for psychosis (Nelson, Thompson & Yung, 2012), and experiences traditionally considered markers of schizophrenia may be found and the non-clinical population too (Peters & Garety, 1996; Verdoux & van Os, 2002). There is a growing consensus that psychotic symptoms exist on a continuum (van Os, Hanssen, Bijl, & Ravelli, 2000).

The extent of psychotic-like symptoms in non-clinical subjects is probably influenced by their degree of sychizotypy – a personality trait characterised by unusual experiences, cognitive disorganisation, introvertive anhedonia and impulsive non-conformity (Mason, Claridge &

Jackson, 1995). Here we focus on schizotypy as a dimension of normal individual differences which correlates with the risk of developing schizophrenia (Cyhlarova & Claridge, 2005). A widely used measure of schizotypy is the Schizotypal Personality Questionnaire (SPQ) (Raine, 1991), which has good reliability and consistent underlying factors (Calkins, Curtis, Grove & Iacono, 2004).

The present study was designed to explore the possibility of assessing self-disorders in a non-clinical sample, especially in high-schizotypy individuals, using the EASE. However, we expected the non-structured interview would not be adequate for use in a non-clinical setting, as other typical sources of information (e.g. clinical observation, patient charts) are not available. Hence, we developed a semi-structured interview with questions designed to provoke the subject to discuss the topics of interest. Participants of high- or low- schizotypy were interviewed, and their interviews rated by two people to determine inter-rater reliability of the assessment.

2. Materials and Methods

2.1. Overview

The study consisted of (1) an internet-based schizotypy screening using the SPQ (Raine, 1991; German version by Klein, Andresen, & Jahn, 1997), and (2) a personal assessment of self-disorders in a sub-sample of participants high or low in schizotypy.

2.2. Participants

The internet screening was advertised on mailing lists for students at the Humboldt-Universität zu Berlin and the Freie Universität Berlin, in a local newspaper, and on a public classified advertisements board. Informed consent was given by all participants before the survey. After the screening, those who were willing to attend a personal assessment were asked for contact information. A total of 1296 participants completed the screening, of which 428 were discarded from further analysis due to having not completed all questions, and SPQ scores for the remaining participants were calculated. Of the remaining 868 participants, those who scored above the 90th percentile (SPQ score >=41, N=129) or below the 10th percentile (SPQ score <=7, N=145) were assigned to the high- and low- SPQ groups, respectively. The cutoff scores are similar to those in Raine (1991), who found a cutoff for SPQ scores at 41 for the 90th percentile and 12 for the 10th percentile.

Participants with a history of head injury or neurological conditions, as assessed through self-

report in the demographic information questionnaire (see "Other assessment instruments"), were excluded from the second part of the study. From the remaining participants, we randomly selected members from the high-SPQ group and the low-SPQ. Sixty-three high-SPQ participants were invited in total (of which 30 accepted), and 25 low-SPQ people (of which 20 accepted). The larger size of the high-schizotypy group is due to the desire to use this data for further analysis, and for future planned experiments using this group.

The demographic data for the final groups were as follows: high-SPQ group: 23 female and 7 male, mean age of 27.5 (SD=6.6) and mean 12.8 years in education (SD=1.7). The low-SPQ group:14 female, 6 male participants, mean age of 32.7 (SD=11.0) and mean 12.6 years in education (SD=0.92).

Before the examination, informed consent was again obtained by all participants for the second part of the study. Participants were reimbursed for their time at a rate of 10€ / hour. The study was approved be the ethics committee of the Institute for Psychology of the Humboldt-University.

2.3. Development and execution of EASE interview

In formalising the EASE checklist into a semi-structured interview, each item was assigned a question. These questions were open-ended and implied a broad definition of the phenomena to encourage participants to address the topic with their own words. Some items had follow-up questions which for more specific information. The interviews were conducted in German. For interview questions translated into English, see appendix. For the German language version used in this study, please contact the corresponding author.

The three interviewers were advanced Psychology students with clinical experience. One author was trained on the use of the EASE, and passed this training on to the interviewers (interviewers trained for around 30 hours total), including understanding the underlying phenomenological constructs of each item, building rapport with participants, and interpreting the descriptions of the participants.

The rating took place after all interviews were completed. The interviewers viewed the full videotapes and rated each item for each participant. Independently, one other interviewer also rated each interview. The second rater did not have access to the participant or to the original

interviewer's notes. In Both the interviewer and the second rater were blind to the schizotypy score.

2.4. Other assessment instruments

The internet-based screening comprised the Schizotypal Personality Questionnaire (SPQ) (Raine, 1991), questions on basic demographic data (age, gender, years and level of education) and a 26-item questionnaire on conspiracy theories, which is not topic of the current paper. The SPQ is a 74-item questionnaire to assess schizotypy, which has high internal reliability (0.91), test-retest reliability (0.82), convergent validity (0.59 to 0.81), discriminant validity, and criterion validity (0.63, 0.68) (Raine, 1991). It is based on the DSM criteria for schizotypal personality disorder (SPD) (American Psychiatric Association, 2000) but was also designed to measure schizotypal traits in non-clinical groups.

In the second part of the study we checked for diagnoses of mental disorders using the German version (Wittchen, Zaudig, & Fydrich, 1997) of the Structured Clinical Interview for DSM-IV (SCID I) (Spitzer, Williams, Gibbon & First, 1994). Three members of the low-SPQ group had a former depressive episode. In the high-SPQ group, eleven members had a former single major depression episode. Three further high-group participants had a recurrent major depressive disorder currently in remission, and two members had bipolar I disorder (both currently in a depressive episode) and two further members had biploar II disorder (one currently in a depressive episode and one currently in remission). None of the participants were currently in treatment for these symptoms. Formerly, four of the high-group and two of the low-group had been in cognitive therapy treatments, but none took medication. There were no other axis I diagnoses in either group. To check whether participants fulfilled the criteria for SPD we applied the respective part of the SCID II interview (Spitzer, Williams, Gibbon & First, 1994; German version by Wittchen, Zaudig & Fydrich, 1997). No participant fulfilled all criteria for SPD.

A demographic data questionnaire of our own design was used to assess age, gender, first language, educational information, current employment, a history of neurological and psychiatric treatment handedness and drug and alcohol use.

2.5. Procedures

Participants were invited through email and telephone communication to an assessment

session at the Institute for Psychology, Humboldt-Universität zu Berlin. After being informed about the aims of the study, participants completed the self-report questionnaires. The participants were interviewed using the modified EASE interview, typically lasting 1.5 to 3 hours. Interviews were video recorded for later rating. Next, the SCID interview was conducted and afterward the participants took part in an eye tracking experiment, which is not a subject of this paper.

2.6. Data analysis

Data was analysed using SPSS 19 (IBM Corp, Armonk, NY) and MedCalc (MedCalc software, Ostend, Belgium).

Inter-rater reliability was calculated using a quadratically weighted kappa for the pair of ratings for each individual item. Kappa is a commonly used method for assessing agreement between raters which corrects for chance agreement and takes frequency into account (Sim & Wright, 2005). As the rating scale is ordinal in nature, the weighted kappa statistic is most appropriate for measuring inter-rater reliability (Stemler, 2004, Fleiss & Cohen, 1973). We chose a quadratic weighting as this can be interpreted as an intraclass correlation coefficient (Schuster, 2004; Brenner & Kliebsch, 1996). Individual kappa scores were averaged across the total sample, to obtain a general estimation of reliability.

Once item kappa scores had been calculated, the subtypes of several items showed poor reliability and were collapsed into a single item. For example, item 1.4 - thought block - has several subtypes (blocking, fading, combination). As these subtypes were not reliable individually, the highest rating from each subtype for each participant was taken as a score for thought block as a single item. Other subtypes collapsed into one item were 1.6 (Ruminations-obsessions), 1.14 (Disturbance of time experience), 2.4 (Diminished presence), 2.7 (I-split), 3.2 (Mirror-related phenomena), and 3.8 (Motor disturbances). Items 2.9 (Identity confusion), 2.10 (Sense of change in relation to chronological age), 2.11.1 (occasional fear of being homosexual) and 2.11.2 (a feeling as if being of the opposite sex) were collapsed into one item, labeled item 2.x.

Another paper which assessed reliability of the EASE used dichotomous rating, with items coded as 0 (absent or questionably present) or 1 (definitely present, all severity levels)

(Møller, Haug, Raballo, Parnas, & Melle, 2011). So we tested the reliability of our data when the ratings were recoded into this dichotomous schema. Each item was recoded as a 0 (for ratings 0 or 1) or as a 1 (for ratings 2, 4 and 5), and the inter-rater reliability calculated again using unweighted kappa statistics.

To address the homogeneity and internal consistency of the different domains we computed Cronbach's alpha and the average inter-item correlation (spearman's rho).

3. Results

3.1. Inter-rater reliability for the EASE

The EASE scores of the total sample (n=50) showed good reliability, with all items scoring a kappa above 0.5 (see Table 1). According to the classification of Landis & Koch (1977), six of the items showed moderate agreement (kappa between 0.41 and 0.60), 44 items showed substantial agreement (kappa between 0.61 and 0.80) and 22 items showed almost perfect agreement (kappa between 0.80 and 1.00). The mean kappa score for all EASE items was 0.76, showing substantial agreement between raters for the score for the whole interview.

When only the high-schizotypy participants were considered (n=30), the reliability was still acceptable but not as good as for all participants (see Table 1). All items scored a kappa above 0.45. Eleven of the items showed moderate agreement, 40 items showed substantial and 21 items showed almost perfect agreement.

For dichotomous scoring, two items showed slight agreement (kappa between 0.21 and 0.4). Twenty-three of the items showed moderate agreement, 35 items showed substantial agreement and 11 items showed almost perfect agreement. Kappa for one item, 4.3.2, could not be calculated as no participant scored more than 0 on this item using dichotomous scoring.

3.2. Internal consistency

Internal consistency for the whole scale was found to be excellent ($\alpha = 0.95$). The average inter-item correlation for the whole scale was moderate ($r = 0.27$).

Internal consistency was also calculated for each domain separately. This data is shown in table 3, alongside mean kappa scores for each domain.

3.3. Psychometric differences between high- and low-SPQ groups

As expected, the high-SPQ group scored significantly higher than the low-SPQ group in the

EASE scale. An independent samples t-test between the high-schizotypical (M=63.27, SD=35.97) and low-schizotypical (M=11.75, SD=10.58) groups was significant; $t(36.10)=7.30$, $p<0.01$. With matched samples only (high n=20; low n=20). An independent samples t-test between the high-schizotypical (M=66.15, SD=36.26) and low-schizotypical (M=11.75, SD=10.58) groups was also significant; $t(22.21)=6.44$, $p=0.01$. Table 4 provides descriptive statistics for total and domain scores of the EASE, and total and subscale scores for the PDI, comparing the scores of the high-schizotypy and low-schizotypy groups.

4. Discussion

The present study sought to explore whether non-clinical participants would report self-disorder symptoms and whether such symptoms can be reliably assessed by a modified version of the Examination of Anomalous Self Experience (EASE). Of special interest was whether the occurrence of self-disorder symptoms depends on psychometrically defined schizotypy, and whether reliable assessment of these symptoms is possible in a sub-sample of participants with a high degree of schizotypical traits.

The results show that the ratings of self-disorder symptoms achieve - on average - substantial inter-rater reliability in a non-clinical sample. Reliability of more than 90% of single items can be considered at least substantial (see Landis and Koch, 1977, for interpretation of magnitude).

When the ratings of symptoms were dichotomised into 0 (absent) and 1 (present), the inter-rater reliability was acceptable but slightly lower for most items. Hence it seems advantageous to have a more gradual rating when assessing self-disorder symptoms in a non-clinical sample.

Finally, inter-rater reliability scores are only slightly lower when looking only at the more homogenous group of participants with a high SPQ score (n=30). Self-disorder symptoms were more common in participants with high SPQ scores, and nine symptoms listed in the EASE were at least mildly present in at least 50% of highly schizotypical participants. These results clearly show that self-disorder symptoms vary with the degree of schizotypy, and that certain symptoms are common in highly schizotypical participants, at least in a mild form.

The prevalence of self-disorder symptoms in the high SPQ group is remarkable, because none

of the participants had been treated for schizophrenia or other psychotic disorder, or fulfilled the DSM criteria for such a disorder. Although the extent of self-disorder symptoms was not directly compared to a patient sample, it seems safe to conclude that people high in schizotypy report self-disorder symptoms in a way that allows reliable rating. In fact, the inter-rater reliability obtained in the present study is comparable to values found in both schizophrenia (Norgaard & Parnas, 2012) and first-admission psychosis patients (Møller et al., 2011).

The association between schizotypy and anomalies of self-experience may not surprise, as the two constructs overlap to some extent. The definition of high schizotypy as provided by the SPQ does include a number of self-disorder like symptoms. However, prior to this study it was not clear to what extent non-clinical participants would report self-disorder symptoms. As shown in table 2, there were a number of symptoms which were at least mildly present in at least 50% of the high SPQ group. Notably, none of these items directly refers to defining traits of the schizotypy concept. For example, thought block, thought pressure, and thought interference belong to the "formal thought disorders" of schizophrenia (Waters & Badcock, 2010) but are not explicit characteristics of schizotypy. The present data suggest that the EASE may be useful to specify the exact nature of such cognitive abnormalities in persons high in schizotypy.

Another symptom with a substantial prevalence in the high-SPQ group (table 2) was hyperreflectivity. The excessive self-monitoring of hyperre*flect*ivity may be conceived as a subset of the exaggerated self-consciousness of hyperre*flex*ivity (see Sass et al., 2013 for discussion of the relation of these two concepts). Hyperreflexivity describes the experience of excessively attending to and analysing the normal processes of the body and mind, hypothesized to be one of the core features of schizophrenia (Sass and Parnas, 2003). Hyperreflexivity has also not been considered a symptom of schizotypy so far. Its substantial prevalence in the high-SPQ group therefore corroborates the notion that participants high in schizotypy report anomalous self-experience that goes beyond the defining traits of the sychizotypy concept and resembles phenomena observed in patients with schizophrenia.

The subscales referring to the EASE's five theoretically-driven domains proved sufficiently homogenous in terms of internal consistency and average inter-item correlation, with the exception of a rather low Cronbach's α for domain four (demarcation/transitivism), likely due

to the small number of item in this sub-scale. Apart from this, the psychometric properties of the subscales suggest the domains represent reliable facets of the general construct of anomalous self-experience. However, sample sizes of the present and earlier studies were not large enough to allow multivariate testing of the theoretically suggested factor structure.

Nevertheless, as the present study showed the applicability of the EASE to non-clinical samples, it may encourage future studies with larger samples. Specifically, it appears desirable to examine a larger group of highly schizotypical participants, as these present with a substantial portion of self-disorder symptoms, which reflect the phenomenological and biological relatedness of schizotypy and schizophrenia. A validated factor structure of anomalous self-experience in schizotypy will improve research in the neurological and cognitive correlates of self-disorder symptoms and thus enable progress in our understanding of self-disorder symptoms in the schizophrenia spectrum.

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Table 1: Kappa scores for each EASE item for all participants (N=50)

Items 1.1-2.x	Kappa (k)			Items 2.12-5.8	Kappa (k)		
	All	High only	Dich score†		All	High only	Dich score†
1.1	0.71 *	0.70 *	0.67 *	2.12	0.77 *	0.80 *	0.56
1.2	0.80 *	0.78 *	0.65 *	2.13.2	0.62 *	0.60	0.60
1.3	0.73 *	0.67 *	0.51	2.13.3	0.80 *	0.73 *	0.68 *
1.4	0.76 *	0.72 *	0.64 *	2.13.4	0.75 *	0.71 *	0.59
1.5	0.81 *	0.80 *	0.74 *	2.13.5	0.80 *	0.77 *	0.62 *
1.6	0.63 *	0.61 *	0.48	2.13.6	0.85 **	0.85 **	0.83 **
1.7.1	0.87 **	0.85 **	0.82 **	2.14	0.81 *	0.78 *	0.50
1.7.2	0.80 *	0.82 **	0.73 *	2.15	0.84 **	0.79 *	0.72 *
1.7.3	0.94 **	0.97 **	1.00 **	2.16	0.60	0.61	0.67 *
1.7.4	0.93 **	0.93 **	0.66 *	2.17	0.83 **	0.80 *	0.70 *
1.8	1.00 **	0.92 **	0.88 **	2.18.1	0.63 *	0.65 *	0.43
1.9	0.88 **	0.87 **	0.76 *	2.18.2	0.65 *	0.66 *	0.73 *
1.10	0.82 **	0.79 *	0.61	3.1.1	0.74 *	0.81 **	0.74 *
1.11	0.94 **	0.94 **	0.77 *	3.1.2	0.68 *	0.67 *	0.79 *
1.12.1	0.82 **	0.79 *	0.78 *	3.2	0.80 *	0.77 *	0.81 **
1.12.2	0.85 **	0.82 **	0.79 *	3.3	0.57	0.67 *	0.54
1.13	0.73 *	0.73 *	0.65 *	3.4	0.71 *	0.77 *	0.78 *
1.14	0.56	0.48	0.43	3.5	0.69 *	0.67 *	0.30
1.15	0.79 *	0.83 **	0.66 *	3.6	0.66 *	0.59	0.30
1.16	0.74 *	0.77 *	0.65 *	3.7	0.57	0.51	0.42
1.17	0.69 *	0.64 *	0.48	3.8	0.80 *	0.75 *	0.44
2.1.1	0.87 **	0.87 **	0.63 *	3.9	0.78 *	0.77 *	0.66 *
2.1.2	0.79 *	0.79 *	0.88 **	4.1	0.86 **	0.85 **	0.79 *
2.2.1	0.62 *	0.57	0.46	4.2	0.92 **	0.92 **	1.00 **
2.2.2	0.74 *	0.70 *	0.50	4.3.1	0.86 **	0.82 **	0.67 *

2.2.3	0.78 *	0.85 **	0.65 *	4.3.2	0.85 **	0.78 *	Insufficient data
2.3.1	0.73 *	0.71 *	0.63 *	4.4	0.58	0.54	0.46
2.3.2	0.60	0.54	0.46	4.5	0.69 *	0.67 *	0.56
2.4	0.64 *	0.58	0.52	5.1	0.90 **	0.89 **	0.79 *
2.5.1	0.82 **	0.78 *	0.61 *	5.2	0.84 **	0.79 *	0.85 **
2.5.2	0.94 **	0.94 **	1.00 **	5.3	0.67 *	0.65 *	0.66 *
2.6	0.65 *	0.63 *	0.51	5.4	0.80 *	0.79 *	0.50
2.7	0.62 *	0.56	0.59	5.5	0.85 **	0.82 **	0.68 *
2.8.1	0.79 *	0.81 *	0.69 *	5.6	0.76 *	0.75 *	0.62 *
2.8.2	0.80 *	0.85 **	0.81 **	5.7	0.80 *	0.90 **	1.00 **
2.x	0.72 *	0.66 *	0.70 *	5.8	0.63 *	0.45	0.49

Note: * Substantial agreement; ** Almost perfect agreement (Landis & Koch, 1977)
† scores coded dichotomously
EASE = Examination of Anomalous Self-Experience

Table 2: Items on which at least 50% of high-SPQ group scored at least mildly present:

Item	Description	*N* Participants scoring at least mildly present (% in brackets)
1.9	Ambivalence	20 (67%)
1.3	Thought pressure	19 (63%)
2.13.3	Anxiety: Subtype 3: phobic anxiety	19 (63%)
1.6	Ruminations-obsessions	18 (60%)
2.6	Hyperreflectivity; increased reflectivity	16 (53%)
2.13.4	Anxiety: Subtype 4: social anxiety	16 (53%)
1.1	Thought interference	15 (50%)
1.4	Thought block	15 (50%)
2.12	Loss of common sense/perplexity/lack of natural evidence	15 (50%)

Note: SPQ = Schizotypal Personality Questionnaire

Table 3: Reliability scores for the five domains of the EASE scale

Domain	Mean Kappa			Cronbach's alpha			Average inter-item correlation		
	high & low	high only	dich coded: all †	high & low	high only	dich coded: all	high & low	high only	dich coded: all †
1	0.80	0.78	0.68	0.89	0.82	0.86	0.24	0.15	0.23
2	0.74	0.73	0.64	0.86	0.77	0.86	0.18	0.11	0.18
3	0.70	0.70	0.58	0.80	0.76	0.79	0.30	0.28	0.27
4	0.79	0.76	0.70	0.57	0.49	0.42	0.23	0.20	0.16
5	0.78	0.76	0.70	0.76	0.72	0.69	0.24	0.18	0.26

Note: † scores coded dichotomously; EASE = Examination of Anomalous Self-Experience

Table 4: Descriptive statistics for EASE and PDI scores comparing high-schizotypy and low-schizotypy groups

	High SPQ group (n=30)		Low SPQ group (n=20)		High and low group combined (N=50)		Effect size	T-test	
	M	**SD**	**M**	**SD**	**M**	**SD**	***d***	**t**	***p***
EASE total score	63.3	36.0	11.8	10.6	42.7	38.2	1.8	7.3	<0.001
EASE Domain 1	26.0	14.8	5.4	5.6	17.8	15.7	1.7	7.0	<0.001
EASE Domain 2	23.6	13.1	4.5	3.9	16.0	14.0	1.8	7.5	<0.001
EASE Domain 3	6.0	6.4	0.7	1.0	3.9	5.7	1.0	4.4	<0.001
EASE Domain 4	3.4	3.5	0.5	0.8	2.2	3.1	1.0	4.3	<0.001
EASE Domain 5	4.3	4.6	0.7	1.8	2.8	4.1	1.0	3.8	<0.001
PDI total	7.4	2.7	2.1	2.2	5.3	3.6	2.1	7.3	<0.001
PDI distress	19.1	11.0	4.0	4.4	13.1	11.7	1.7	6.8	<0.001
PDI preoccupation	20.3	9.7	4.4	4.9	13.9	11.3	2.0	7.6	<0.001
PDI conviction	21.3	9.3	6.6	7.7	15.4	11.3	1.7	6.1	<0.001

Note: SPQ = Schizotypal Personality Questionnaire;
EASE = Examination of Anomalous Self-Experience;
PDI = Peters Delusions Inventory

Appendix: Interview questions

1 Cognition and stream of consciousness

1.1 Thought interference

Do thoughts ever pop into your head unbidden or do you ever have thoughts which feel strange to you?

If yes: Do these thoughts ever break your line of thinking?

1.2 Loss of thought ipseity ('Gedankenenteignung')

Do your thoughts sometimes feel strange, as if they do not belong to you?

Do you sometimes have the feeling that someone is reading with you while you are reading a book, even if no one is there?

1.3 Thought pressure

Do you ever feel as if there are so many thoughts in your head that you cannot keep track of them all?

Does it ever feel as if thoughts are pressing out from inside your head?

1.4 Thought block

Do thoughts ever stop abruptly, slip away or empty from your mind entirely?

If yes: Do the thoughts fade gradually, or do they disappear suddenly?

1.5 Silent thought echo

Do you ever feel that thoughts are echoing in your head?

1.6 Ruminations-obsessions

Do you ever feel that you have to think about something over and over again? Or that thoughts come again and again, without you wanting them to?

If yes: When are these situations? What are you thinking about?

If unclear: Do you know why it is that you think about some things very often?

If unclear: Do you have to think about things a lot because you find them confusing, or because you feel depressed?

If yes: Do you feel as if these thoughts are irrelevant or ridiculous? What is the content of these thoughts?

If yes: Are these thoughts about aggressive or sexual acts? Do you find the content of these thoughts unpleasant or disgusting?

If yes: Are there any actions or rituals which you perform because of these thoughts?

1.7 Perceptualization of inner speech or thought

Do you ever feel that you can hear or see your own thoughts?

If yes, do you hear them as if they came from inside your head or outside?

Do you feel like your thoughts are being written down?

Are your thoughts ever so loud that other people can hear them?

Do you ever feel like your thoughts are echoing or resonating outside of your head?

1.8 Spatialization of experience

Do you ever feel that thoughts or feelings are occurring just within one specific area of your head?

1.9 Ambivalence

Do you find it hard to decide between two or more options?

1.10 Inability to discriminate modalities of intentionality

Do you ever feel uncertain about whether what you are experiencing is happening right now or is a memory or fantasy?

1.11 Disturbance of thought initiative/intentionality

Do you ever find it difficult to get all your thoughts in order so that you can act accordingly? For example, when you are cooking or writing an essay.

1.12 Attentional disturbances

Do you sometimes find it hard to pay attention to something because you are so distracted by particular details?

Do you sometimes have difficulty in paying attention to several things at once?

1.13 Disorder of short-term memory

Are you forgetful? Do you find it difficult to keep information in your mind a long period of time?

1.14 Disturbance of time experience

Do you ever have the strange feeling that time is rushing ahead or slowing down suddenly?

Do you ever feel as if your whole life takes place only now or only in the past?

1.15 Discontinuous awareness of own action

Do you ever find yourself somewhere and not remember how you got there?

1.16 Discordance between expression and expressed

Do you sometimes feel that what you show to the outside world, such as how you behave or how your face appears to other people, does not adequately represent the way that you feel?

1.17 Disturbance of expressive language function

Do you ever find it difficult to find the right words for what you want to say?

2 Self-awareness and presence

2.1 Diminished sense of basic self

Do you feel that you might not exist at all?

Do you ever feel unsure about who you are?

Do you find it difficult to form your own opinions on issues, even when you are familiar with the subject?

If yes: Did you first feel like this as a child or a teenager?

2.2 Distorted first-person perspective

Do your thoughts ever feel like they don't belong to you?

Do you ever feel that you do not control your own actions?

Do you ever feel like you are unsure where your body is? Does it feel as is your body is sitting behind your actual self?

2.3 Psychic depersonalization (self-alienation)

Do you ever feel that you have moved away from yourself, or are there moments in which you feel that who you are has changed?

If yes: Do you feel this way at times when you are deeply depressed?

2.4 Diminished presence

Do you find it difficult to be effected or touched by outside events or other people?

If yes: Is this because you feel that there is a barrier between you and the world?

If yes: Is this because you feel that your perceptions are faded – e.g. that colours seem muted?

2.5 Derealization

Do you ever find your surroundings are strange, meaningless or lifeless?

If yes: Is this a general impression of the world around you, or is it only specific details?

2.6 Hyperreflectivity; increased reflectivity

Do you sometimes have to think about yourself or other things very intensively? Does this make it difficult for you to act spontaneously, or make everyday actions like eating or drinking difficult?

2.7 I-split ('Ich-Spaltung')

Do you ever feel that your self has been divided into more than one part?

If yes: Do you feel as if you had been divided, or are you really made of many parts?

If yes: Can you feel these different parts in certain places in your body? For example, that part of your self is in your left hand?

If yes: Why do you think that you feel this way?

2.8 Dissociative depersonalization

Have you ever had an out-of-body experience - the feeling of having left your body and being able to see yourself from the outside?

If yes: Did you imagine this experience and see it in your "mind's eye", or did you literally leave your body?

If yes: During this experience, were you able to see yourself from the outside?

2.9 Identity confusion

Do you ever feel as if you are someone else?

2.10 Sense of change in relation to chronological age

Do you ever feel like you are very much younger or older than you are?

2.11 Sense of change in relation to gender

Are you sometimes unsure about your gender?

Do you have problems with your sexual orientation?

2.12 Loss of common sense/perplexity/lack of natural evidence

Do you sometimes think intensively about simple things, such as why it is that traffic lights have three colours?

2.13 Anxiety

Do you sometimes feel suddenly very afraid or panicked? Do you experience fear of dying, or bodily symptoms like finding it hard to breathe, shivering, feeling dizzy or breathing quickly?

Do you have strong feelings of anxiety or panic without the bodily symptoms just described?

Do you feel like this when confronted by something specific – for example, heights, small rooms or certain animals?

Do you feel like this when you are in social situations, such as a work meeting or a party?

Do you feel anxious and tense all the time, for no particular reason?

Do you feel anxious because other people mean to harm you?

2.14 Ontological anxiety

Do you think that the world is a dangerous place?

Do you often feel like something bad is about to happen?

Do you feel exposed to the world and other people?

2.15 Diminished transparency of consciousness

Do you have the constant feeling that you are not fully conscious, or that you are not entirely there?

Do you feel as if there is a always a veil over your thoughts and feelings?

2.16 Diminished initiative

Are there some things that you want to do, but find it hard to get started?

2.17 Hypohedonia

Do you find it hard to experience pleasure, such as when eating food, reading a book or having sex?

What do you take pleasure from in life?

2.18 Diminished vitality

Do you often feel tired, exhausted and lacking in energy?

If yes: How often do you feel this way? How long does this feeling last?
If yes: Can you explain why you feel this way?

3 Bodily experiences

3.1 Morphological change

Do you ever feel like part of your body is getting larger or smaller?
Or as if it has become very heavy or very light?
If yes: Does this feeling happen in one particular part of your body, or is it all over?
If yes: Are these changes visible to you?

3.2 Mirror-related phenomena

Have you ever looked in a mirror and felt that your face has changed?
Or do you look in the mirror often because you are afraid of such changes?
Or do you avoid looking in the mirror, because you are afraid of such changes?

3.3 Somatic depersonalization (bodily estrangement)

Do parts of your body ever feel as if they are wrong; like your body does not fit together properly?

3.4 Psychophysical misfit and psychophysical split

Do you ever feel as if you don't fit into your body? For example, do you have the impression that your body is too big or too small?

3.5 Bodily disintegration

Does it ever feel as if your body disintegrates, dissolves into pieces or vanishes?

3.6 Spatialization (objectification) of bodily experiences

Did you ever feel overly aware of parts of your body? For example, can you feel the roar of blood under your skin?
If yes: Do you experience this as overpowering?

3.7 Cenesthetic experiences

Do you ever have unusual sensations in your body, such as numbness, stiffness, unexplained pain, tingling, electric sensations or unexplained warmth or coldness?

3.8 Motor disturbances

Do you sometimes feel as is parts of your body have moved, when they have not?
Do parts of your body ever move without you meaning them to?
Do you ever find yourself suddenly unable to move or speak, as if your movements are blocked?
Do you ever have a sudden feeling of weakness in your arms or legs, like you drop something because your hands suddenly become very weak?
Do you ever find it difficult to perform habitual actions such as getting dresses or brushing your hair?

3.9 Mimetic experience

Do you ever feel as if there is a link between your movements and someone else's? Like other people are mirroring the way that you move?

4 Demarcation/transitivism

4.1 Confusion with the other

Do you ever feel as if your thoughts or feelings are mixed up with someone else's?

4.2 Confusion with one's own specular image

When you look in a mirror or at a photo of yourself, do you ever feel confused about whether you are still yourself or if you are the reflection or image?

4.3 Threatening bodily contact and feelings of fusion with another

Do you find it threatening when other people come close to you or touch you? Do you feel this way even when you know the other person well?

If yes: Can you explain why this frightens you?

Do you ever feel that you might stop existing when you are close to another person?

4.4 Passivity mood ('Beeinfl ussungsstimmung')

Do you often have the feeling that something very bad is going to happen to you, without you being able to influence it? Do you have a concrete idea of what it will be?

4.5 Other transitivistic phenomena

Are you sometimes unsure about where the boundary is between you and the outside world?

Do you ever feel that you are too open to the influences of the outside world? Or do you feel as if you have very thin skin?

5 Existential reorientation

5.1 Primary self-reference phenomena

Do you sometimes experience an immediate connection between yourself and external events or other people – for example, that your behaviour is reflected in the clouds?

5.2 Feeling of centrality

Do you feel as if you are the center of the world or that everything that happens in the world is dependent on you?

5.3 Feeling as if the subject's experiential field is the only extant reality

Do you ever feel that things stop existing when you close your eyes?

5.4 'As if' feelings of extraordinary creative power, extraordinary insight into hidden dimensions of reality, or extraordinary insightinto own mind or the mind of others

Do you feel as if you have special powers or special knowledge about the world?

5.5 'As if' feeling that the experienced world is not truly real, existing, as if it was only somehow apparent, illusory or deceptive

Do you ever feel for a moment that the world is not really there?

Do you sometimes get the impression that the world is an illusion or trick?

If yes: Does it feel that way to you too?

5.6 Magical ideas linked to the subject's way of experiencing

Do you sometimes feel that something changes in the world, because you have done or thought something in particular? For example, is the weather changed by your mood?

5.7 Existential or intellectual change

Have you been unusually absorbed in topics such as religion, the supernatural or philosophy?

If yes: What made you interested in these things?

5.8 Solipsistic grandiosity

Do you have the impression that in contrast to you, other people are silly or ignorant? For example, that other people are preoccupied with shallow things?

Is everything that you're interested in very important?

6.3. Paper 3: Volitional and visually-guided saccades in non-clinical schizotypical populations

Authors & affiliations:

G. Torbet [1,2], N. Kathmann[2], B. Reuter[2]

[1] Berlin School of Mind and Brain, Berlin, Germany, [2] Humboldt-Universiät zu Berlin, Berlin, Germany

Corresponding author:

Georgina Torbet, Humboldt-Universität zu Berlin, Luisenstraße 56, 10115 Berlin, Tel: +49 1763 9292575, Email: georgina.torbet@gmail.com

Abstract:

Schizophrenic subjects are known to show normal or faster visually-guided saccades but slower volitional saccades, compared to healthy controls. A somewhat similar pattern of performance can be found in non-clinical high-schizotypy people. We considered that this performance may be related to the level of self disorder symptoms found in high-schizotypy people.

The aim of the present study was to investigate the relationship between schizotypy, disorders of self, visually-guided and volitional saccades in people who are non-clinical but high in psychometrically-defined schizotypy. We examined participants with either high (n=13) or low (n=13) schizotypy scores on an eye tracking experiment involving both visually-guided and volitional saccades. Median latencies for each condition were compared between the high and low schizotypy groups. There were no significant group differences between latencies in any condition.

In the group with high schizotypy scores, a strong negative correlation was found between self-disorder scores and latencies on cued and uncued visually-guided saccades (-0.66 and -0.70 respectively). No significant correlation was found between latencies and schizotypy scores in this group. As such, faster latencies for visually-guided saccades were shown to be associated with self disorders specifically, not with schizotypy generally. This provides first evidence of a ink between self disorder symptoms and performance on eye movement tasks.

Introduction

Saccades, eye movements characterised by short latencies (~200ms) and brief durations (between 20 and 120ms) (Gooding & Basso, 2008), have been a major topic in schizophrenia research. Saccades can be classified into two types: slower volitional saccades and faster visually-guided saccades.[1] Schizophrenic patients are unimpaired on visually-guided saccades but impaired on volitional saccades (Reuter & Kathmann, 2004). The unimpaired visually-guided saccades demonstrate that it is the generation and/or execution of a willed action specifically that is impaired in slower volitional saccades. Much investigation has focused on the antisaccade task (e.g., Fukushima et al., 1988; 1990; Clementz et al., 1994; Katsanis et al., 1997), in which the appearance of a target induces a visually-guided saccade which must be overridden by a volitional saccade in the opposite direction (Hutton & Ettinger, 2006). Patients with schizophrenia are impaired on this task, showing more errors than controls, suggesting a difficulty in inhibiting reflexive behaviours (see Reuter et al., 2007 for a review).

Despite extensive research, there remains a lack of clarity regarding the relationship between cognitive deficits and the specific symptoms of schizophrenia. In order to examine this relationship without the confounds of medication and/or general cognitive impairment, non-clinical high-schizotypy subjects can be investigated. Schizotypy is a psychometric measure of a dimension of uncommon and odd experiences and behaviours which relates to increased risk for developing schizophrenia (Cyhlarova & Claridge, 2005), and it is predicted that schizotypical individuals would show similar patterns of performance on eye movement tasks to schizophrenia patients. Highly schizotypical but non-clinical populations thus provide an important source of knowledge about the symptoms of schizophrenia spectrum disorders in the context of healthy functioning.

High-schizotypy individuals have been shown to make more errors on the antisaccade task than controls (Holzman et al, 1995; O'Driscoll et al., 1998; Gooding, 1999). On visually-guided saccade tasks, most studies have found no difference in saccade accuracy or latency when comparing high-schizotypy individuals to controls (e.g., Gooding, 1999; Klein et al., 2000; Aichert et al., 2012). However, a study by Ettinger et al. (2004) found that latency on visually-guided saccades was reduced in high-schizotypy participants with thought disorder

1 fast saccades are often referred to in the literature as *reflexive*, however the term *visually-guided* is used here because such saccades are not necessarily purely reflexive, but may involve a degree of volitionality (Hutton et al., 2008).

symptoms. This demonstrates that performance on visually-guided saccades may be enhanced in schizophrenia spectrum conditions. However, no study has compared performance of simple volitional saccades and visually-guided saccades in schizotypical people.

Some findings imply that the impairments in saccades seen in schizotypy studies are distinct to a subgroup with the high-schizotypy population (Gooding, 1999; Klein et al., 2000; Smyrnis et al., 2003). We thus sought to identify factors within high-schizotypy populations which could be related to saccade task performance. We considered the level of self disorders as a possible candidate: symptoms such as the dissolution of the boundary between self and world, difficulty in distinguishing experience from a memory or a dream, or feeling as if the body is the wrong shape or size to hold the mind (Cermolacce, Naudin, & Parnas, 2007), which have traditionally been considered paradigmatic of schizophrenia (Simms, 1991). Recent research shows that highly schizotypical non-clinical people do also experience varying levels of self disorder symptoms (Torbet et al., in preparation), providing an opportunity to relate symptoms of schizophrenia to the cognitive impairments found in saccade task performance.

The first research question we aimed to address was whether high-schizotypy people show the same pattern of normal or enhanced visually-guided saccades and impaired volitional saccades as schizophrenic people. We hypothesized that shorter visually-guided latencies and longer antisaccade and volitional latencies would also be found in high-schizotypy individuals, due to an underlying deficit common to the schizophrenia spectrum. Visually-guided latencies are shorter because schizophrenia spectrum individuals are more stimulus-bound and therefore react quickly to changes in the world. This same stimulus-boundness makes antisaccade latencies slower, because the effect of the stimulus must be inhibited in order to make the correct movement. It would be expected that simple volitional saccade latencies would also be slower, as they are internally initiated and must be induced without a change in external stimulus.

The second research question we aimed to address was whether performance on eye movements tasks was associated with the presence of self disorder symptoms among high-schizotypy individuals. We hypothesized that higher levels of self disorders would be related to shorter visually-guided latencies and longer antisaccade and volitional latencies.

Thus we determined to investigate the relationship between schizotypy, self disorders, and

volitional and visually-guided saccades.

Methods & Materials

Participants

Participants were recruited through an online survey process, which used the Schizotypal Personality Questionnaire (SPQ) (Raine, 1991) to measure psychometric schizotypy. The SPQ has 74 items and is based on the DSM IV criteria for schizotypal personality disorder (American Psychiatric Association, 2000) but may also be used for non-clinical groups. The survey was advertised on mailing lists for students at the Humboldt-Universität zu Berlin and the Freie Universität Berlin, in a local newspaper, and on a public classified advertisements board. We also gave a questionnaire on basic demographic data, including age, gender, years and level of education, and a questionnaire on conspiracy theories which addressed additional research questions which are not topic of the present paper. Informed consent was given by all participants before the survey was completed.

If participants completed the screening and were willing to be invited for a personal assessment, they were asked for contact information. 1296 people completed the online survey, of which 428 results were discarded from further analysis due to having not completed all questions. SPQ scores for the remaining 868 participants were calculated. Those who scored above the 90th percentile (SPQ score >=41, N=129) or below the 10th percentile (SPQ score <=7, N=145) were assigned to the high- and low-schizotypy groups, respectively. The cut-off scores are similar to those in Raine (1991), who found a cut-off for SPQ scores at 41 for the 90th percentile and 12 for the 10th percentile.

Participants from the high- and low-schizotypy groups were invited to attend an experimental session in which they completed questionnaires, undertook an interview regarding self disorder symptoms (which is not the subject of this paper) and took part in the eye tracking experiment. 63 high-schizotypy people were invited in total (of which 30 accepted), and 25 low-schizotypy people (of which 20 accepted).

46 people completed the eye tracking experiment. Due to technical problems, the data of 20 people had to be excluded from further analysis. The remaining groups were 13 high-schizotypy participants and 13 low-schizotypy participants. Groups did differ significantly in age (high: 25 years ±4.75 SD, low: 32 ± 10.13SD, $p=0.01$), but not sex (high: 10 female, low: 8 female, $X2(1)=0.181$, $p=0.67$) or years spent in education (high: 13.10 years ±2.28 SD, low: 12.55 ± 1.04SD, $p=0.82$).

We checked for diagnoses of mental disorders using the German version (Wittchen, Zaudig, & Fydrich, 1997) of the Structured Clinical Interview for DSM-IV (SCID I) (Spitzer, Williams, Gibbon & First, 1994). In the high-schizotypy group, four members had a former single major depression episode and one had a recurrent major depressive disorder currently in remission. One further high-schizotypy group member had bipolar I disorder (currently in a depressive episode) and one had biploar II disorder (currently in remission). None of the participants were currently in treatment for these symptoms. Formerly, three of the high-group had been in cognitive therapy treatments, but none took medication. There were no other axis I diagnoses. No member of the low-schizotypy group had a diagnosis. In order to check whether participants fulfilled the criteria for a schizotypical personality disorder we applied the respective part of the SCID II interview (Spitzer, Williams, Gibbon & First, 1994; German version by Wittchen, Zaudig & Fydrich, 1997). No participant fulfilled all of the criteria for schizotypical personality disorder.

Assessment instruments used

We measured self disorders using a modified version of the Examination of Anomalous Self-Experience (EASE) scale (Parnas et al., 2005) which has been shown to have good reliability in non-clinical populations (Torbet et al., in preparation). This semi-structured interview technique consists of open-ended questions regarding 72 symptoms related to disruptions of self. The interviews were videotaped and later each participant was rated for the presence of these symptoms. Each symptom was rated on a 4-point Likert scale (0=absent, 1=questionably present, 2=present[mild], 4=present[moderate], 5=present[severe]) and ratings for all symptoms were summed to create a score of self disorders.

Eye tracking task and procedure

Participants sat in a dimly lit cabin in front of a monitor on which the task was presented. A chin rest and foot rest were used to reduce body movements. The 17 inch monitor was 20 inches away from the eyes of the participants. Stimuli were presented using Presentation version 16.3 (Neurobehavioural Systems, Inc) and recorded using the EyeLink system version 2.22 (SR Research).

Each block began with the experimenter explaining the conditions to the participant.

Instructions were also presented as text on the screen. Each block consisted of 10 practice trials, followed by 40 actual trials. Each trial began with the participant fixating on a central cross. After 1000-2000ms (randomised per trial), a symbol was changed on screen to signal that the participant should execute an eye movement. The symbol was a hexagonal arrow, width 0.44°, height 0.26° (see Figure 1). The symbol pointed to the left or the right and indicated the direction of eye movement required differed for each block. On half of trials the target for the eye movement was on the left, and on the other half it was on the right. Stimuli were presented in white on a black background. Blocks were presented in a pseudo-randomised order.

The experiment included seven different eye movement conditions, as follows (Kloft et al., 2013, also see Figure 1): Cued and uncued simple volitional saccades (CSV and USV, respectively) involved targets on both left and right sides, and a change in central stimulus which indicated the direction in which the eye movement should be directed. In the cued condition, the direction of the instruction was indicated before the change took place, but not in the uncued condition. Cued and uncued visually-guided saccades (CVG and UVG) were investigated, which were similar to the simple volitional saccades, except that there was also a change in the target stimulus at the time of central change. An antisaccade (ANT) task was included, in which the participants were instructed to execute an eye movement in the opposite direction to the target.

These saccade tasks represent different levels of volitional or agentic experience. A visually-guided saccade is a stimulus-driven, somewhat automatic reaction to a change in environment, and can thus be understood as primarily reflexive. A simple volitional saccade is self-initiated and agentic, and so is best understood as volitional. The antisaccade task is also considered volitional as it requires the inhibition of a reflexive movement by a volitional one.

The cued and uncued conditions serve to distinguish subcomponents of response selection and initiation, based on previous empirical findings that people with schizophrenia are impaired on saccade initiation specifically (Reuter et al., 2007).

We also considered whether experiences of volition would be effected by different sensory modalities, and to this end we decided to investigate performance on tasks where the signal to execute a saccade was given by an auditory tone. Two conditions similar to the CSV were included in which the signal which indicated the time to make an eye movement was given by an auditory tone. In one condition, the tone was presented simultaneously with the central

change of the symbol (CSV + sound). In another, the tone was presented alone, without a central change (CSV sound only).

Data analysis

Data was analysed using SR Research Data Viewer 1.10 (SR Research) and SPSS 19 (IBM Corp). Saccades were detected when velocity of eye movement was at least 31°/s, acceleration was at least 100°/s^2, and position changed by more than 1°. Analysis was performed on a time window from 800ms before the central change signal for a duration of 1200ms. Trials were excluded for meeting any of the following criteria: 1) no saccade occurred within the time window, 2) the subject did not fixate in the centre from 800ms onwards, 3) a blink occurred between 800 and 1000ms after the start signal, 4) any recording gaps larger than 150ms occurred. Saccades which occurred between 200ms before and 80ms after the start signal were classified as anticipatory saccades.

The median latency of correct saccades was determined for each subject in each of the seven conditions. A one-way ANOVA was conducted to compare the effect of group (high versus low schizotypy), cue (cued versus uncued conditions), and volition (volitional versus visually-guided conditions) on saccade latencies. Correlations between variables in the high-schizotypy group were also investigated using a bivariate correlation to find the Pearson product-moment correlation.

Results

Accuracy

The percentage of errors made is presented in table 1. A within-subjects ANOVA of percentage of error trials found a significant effect of cue (cued versus uncued), $F(1,24)=5.08$, $p=0.03$ and of volition (stimulus-driven versus volitional saccades), $F(1,24)=6.34$, $p=0.02$. A trend was found towards an interaction of volition x cue x group (high or low schizotypy), $F(1,24)=3.32$, $p=0.08$.

Latencies

A within-subjects ANOVA of latencies for correct saccades found a significant effect of cue (cued versus uncued), $F(1,24)=53.31$, $p<0.01$; of volition (stimulus-driven versus volitional saccades), $F(1,24)=59.14$, $p<0.01$; and a volition x cue interaction, $F(1,24)=20.08$, $p<0.01$.[2] Because of this interaction between volition and cue, posthoc t-tests were performed to test specific hypotheses. No significant difference between high and low groups was found in latencies in any condition (see table 2). However, latencies of antisaccades were in the expected direction and showed a medium effect size, $t(24) = 1.28$, $p=0.21$, $d=0.50$, with high-schizotypy subjects showing faster latencies ($M=262.92$, $SD=51.68$) than low-schizotypy subjects ($M=285.38$, $SD=36.76$). Latencies of the cued visually-guided saccade task were also in the expected direction and showed a medium effect size, $t(24) = 1.17$, $p=0.25$, $d=0.46$, with high-schizotypy subjects showing faster latencies ($M=205.54$, $SD=21.25$) than low-schizotypy subjects ($M=220.00$, $SD=39.17$).

Analysis of correlations between EASE score and latencies focused on the high-schizotypy group only, because there was large variance of EASE score in the high group ($M=59.46$, $SD=32.71$) but not in the low group ($M=12.46$, $SD=12.38$). In the high group ($N=13$), there was a strong correlation between EASE score and latencies for cued visually-guided saccades, $r(11)=-0.66$, $p=0.02$, and also for uncued visually-guided saccades, $r(11)=-0.70$, $p=0.01$. These correlations were also found in the high- and low- schizotypy groups combined ($N=26$) for cued visually-guided saccades, $r(24)=-0.51$, $p=0.01$, and uncued visually-guided saccades, $r(24)=-0.42$, $p=0.03$. Figures 2 and 3 show scatter plots of latencies versus EASE score in the high- schizotypy group for cued and uncued visually-guided saccades, respectively. Other

2 To test the effect of age on latencies, an exploratory within-subjects ANOVA was performed with age as a covariate. This found no significant effects, though a trend of cue remained, $F(1,24)=4.18$, $p=0.53$. Further, age was not significantly correlated with any of the latencies.

correlations between EASE and latencies in the high-schizotypy group were not significant. Correlations between EASE and saccadic latencies, and between SPQ and saccadic latencies, are presented in table 3.

Discussion

This study sought to investigate the relationship between two psychological factors (schizotypy and self disorders) and two types of saccadic eye movement (visually-guided and volitional). It is well established in the literature that people with schizophrenia have unimpaired or enhanced visually-guided saccades but impaired volitional saccades (Reuter & Kathmann, 2004), and we investigated whether this pattern would hold for non-clinical high-schizotypy people. We found no significant differences in latencies of either visually-guided or volitional saccades between high- and low-schizotypy groups, which is in line with previous findings regarding visually-guided saccades in schizotypical people (Gooding, 1999; Klein et al., 2000). Our study expands upon these results by comparing simple volitional saccade and visually-guided saccade conditions, which had not previously been investigated in schizotypical people. These simple volitional saccades were also found to be unimpaired in schizotypical people, unlike people with schizophrenia who are typically impaired on this task (Reuter & Kathmann, 2004). This provides evidence that schizotypical people do not share the slowed volitional response latencies as schizophrenia patients, even though they do make more errors on the antisaccade task. This could indicate that schizotypical people are impaired in the inhibition of reflexive movements, rather than on the production of volitional movements.

The high-schizotypy group had shorter average latencies than the low-schizotypy group on visually-guided saccades. Although this difference was not significant when compared with a t-test, the effect sizes were reasonable. This is in line with previous findings of enhanced visually-guided saccades in schizophrenia (Reuter et al., 2007). Our sample was too small to detect this effect at a significant level, but future research with a larger sample may reveal these effects.

We also found the expected pattern of the high-schizotypy group having longer lantencies on simple volitional saccades than the low-schizotypy group, but this difference was not significant. Surprisingly, the high-schizotypy group showed longer latencies on the antisaccade task than the low-schizotypy group, as we would have expected the opposite, but again the difference was not significant. There were no significant difference between groups in the volitional saccade with sound conditions.

We also investigated the relationship between performance on eye movements task and self

disorders. Particularly notable for its novelty is our finding of a strong negative correlation between latencies for visually-guided saccades and self disorder scores. No significant correlations were found between EASE score and latencies of simple volitional saccades or antisaccades, or between SPQ score and latencies on any conditions. So faster visually-guided saccades are related specifically to self disorders, not generally to schizotypy. This is the first time that a link from self disorder symptoms to performance on eye movement tasks has been made in the literature.

These finding can be understood in the light of theoretical work into disorders of self in the schizophrenia spectrum. Deficits in the feeling of volitionality or control over one's actions is related to the disturbance of ipseity or "mineness" of action in self disorders (Sass & Parnas, 2003). There is also some overlap between self disorders and unusual experiences of agency over one's body, such as in delusions of control in which patients believe that their bodily movements are being executed by another person (Blakemore, Oakley & Frith, 2003). Self disorders have been linked to disorders of self-monitoring and thus to anomalous experiences of agency, as schizophrenia patients high in self disorders are less able to correctly identify their own actions (Kircher & Leube, 2003).

Given this link between self disorders and disruptions in the sense of agency, our finding of a strong negative correlation between self disorders and visually-guided saccade latencies is especially relevant. Our findings supporting our hypotheses that people with high levels of self disorders would respond faster to changes in the environment than people without self disorders, because they are more receptive to or influenced by events in the outside world. This is supported by empirical findings that schizophrenia patients with delusions of control make more mistakes on self-recognition paradigms than controls, mistaking the movement of another person for their own (Jeannerod et al., 2003), and that high-schizotypy subjects had a weaker sense of self-agency than controls when feedback of their actions was distorted spatially (Asai and Tanno, 2007).

Some studies investigating high-schizotypy populations have found that impaired performance on saccade tasks is particularly prominent in a subgroup who score very high on schizotypy (>2SD above the mean) (Gooding, 1999; Klein et al., 2000; Smyrnis et al., 2003). These very high schizotypy individuals could also be those experiencing self disorders, however, this could not be confirmed in this study as no individual scored more than 2SD above the mean on the SPQ. and it may be that comparing individuals who score high and

low on self disorder symptoms would show group differences in saccadic latencies, but that this effect is not strong enough to be found in groups based on schizotypy scores. Hence future research into eye movements in schizotypy may benefit from assessing levels of self disorders as well.

Some limitations of the study must be considered. Firstly, there was a significant difference in age between the high- and low-schizotypy groups, with the low-group being older. It may be that this difference in age affects latencies, however, the lack of significant correlation between age and latencies argues against this. A further limitation is regarding the large percentage of trials on which an error was made across the sample. There were non-significant differences between groups in the number of errors made, with the high-schizotypy group making more errors on uncued simple volitional saccades and cued simple volitional saccades with sound. However, these error data are not reliable as due to technical issues we found an unusually high number of errors on volitional saccades in both groups compared to other studies.

Conclusion

Using eye tracking paradigms, we investigated the relationship between schizotypy, self disorders and visually-guided and volitional saccades. To extend the findings of impaired volitional saccades but unimpaired visually-guided saccades in schizophrenia, we compared latencies of simple volitional saccades in a high-schizotypy but non-clinical group to a low-schizotypy non-clinical group. We found that simple volitional saccades were unimpaired in our high-schizotypy group. No significant difference in latencies between groups was found in any task. We did identify a strong negative correlation between visually-guided saccade latency and self disorder score. This may provide the basis for fruitful future research into eye movements, such as examining whether schizophrenia patients with high levels of self disorders are more impaired on volitional saccades than patients without self disorders.

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Tables

Table 1: descriptive statistics and effect sizes for percentage of errors by condition, comparing high-schizotypy (N=13) versus low-schizotypy (N=13) groups.

Description	Low group		High group		*t*	*p*	*d*
	M	SD	M	SD			
Cued simple volitional saccades	1.89%	4.72	1.48%	2.45	0.28	0.78	0.11
Uncued simple volitional saccades	3.36%	3.37	6.18%	6.83	-1.33	0.20	-0.52
Antisaccades	16.48%	21.23	19.70%	23.68	-0.36	0.72	-0.14
Cued visually-guided saccades	0%	0	0%	0	-	-	-
Uncued visually-guided saccades	3.15%	10.45	0.21%	0.75	1.01	0.32	0.4
Cued simple volitional saccades with sound	0%	0	7.69%	27.74	-1.00	0.33	-0.39
Uncued simple volitional saccades with sound	0%	0	0%	0	-	-	-

Table 2: descriptive statistics, t-tests and effect sizes for latencies of correct saccades by condition, comparing high-schizotypy (N=13) versus low-schizotypy (N=13) groups.

Description	Low group		High group		*t*	*p*	*d*
	M	SD	M	SD			
Cued simple volitional saccades	258	44	266	80	-0.33	0.74	-0.13
Uncued simple volitional saccades	324	38	338	81	-0.57	0.58	-0.22
Antisaccades	285	37	263	52	1.28	0.21	0.50
Cued visually-guided saccades	220	39	206	21	1.17	0.63	0.46
Uncued visually-guided saccades	225	38	219	27	0.49	0.63	0.19
Cued simple volitional saccades with sound	220	35	233	59	-0.66	0.51	-0.26
Uncued simple volitional saccades with sound	214	23	207	40	0.53	0.60	0.21

*Table 3: correlation matrix of EASE, SPQ and latencies for high-schizotypy (N=13) group. values marked with * are significant at p<0.05 and ** at p<.01.*

		Latencies				
		CSV	USV	ANT	CVG	UVG
EASE	Pearson's r	-.453	-.242	-.351	-.656*	-.701**
	p-value	.120	.425	.240	.015	.008
SPQ	Pearson's r	.037	.282	-.137	-.277	-.229
	p-value	.905	.351	.654	.360	.451

Abbreviations: EASE: Examination of Anomalous Self-Experience; SPQ: Schizotypal Personality Questionnaire; CSV: cue simple volitional saccades; USV: uncued simple volitional saccades; ANT: antisaccades; CVG: cued visually-guided saccades; UVG: uncued visually-guided saccades.

Figures

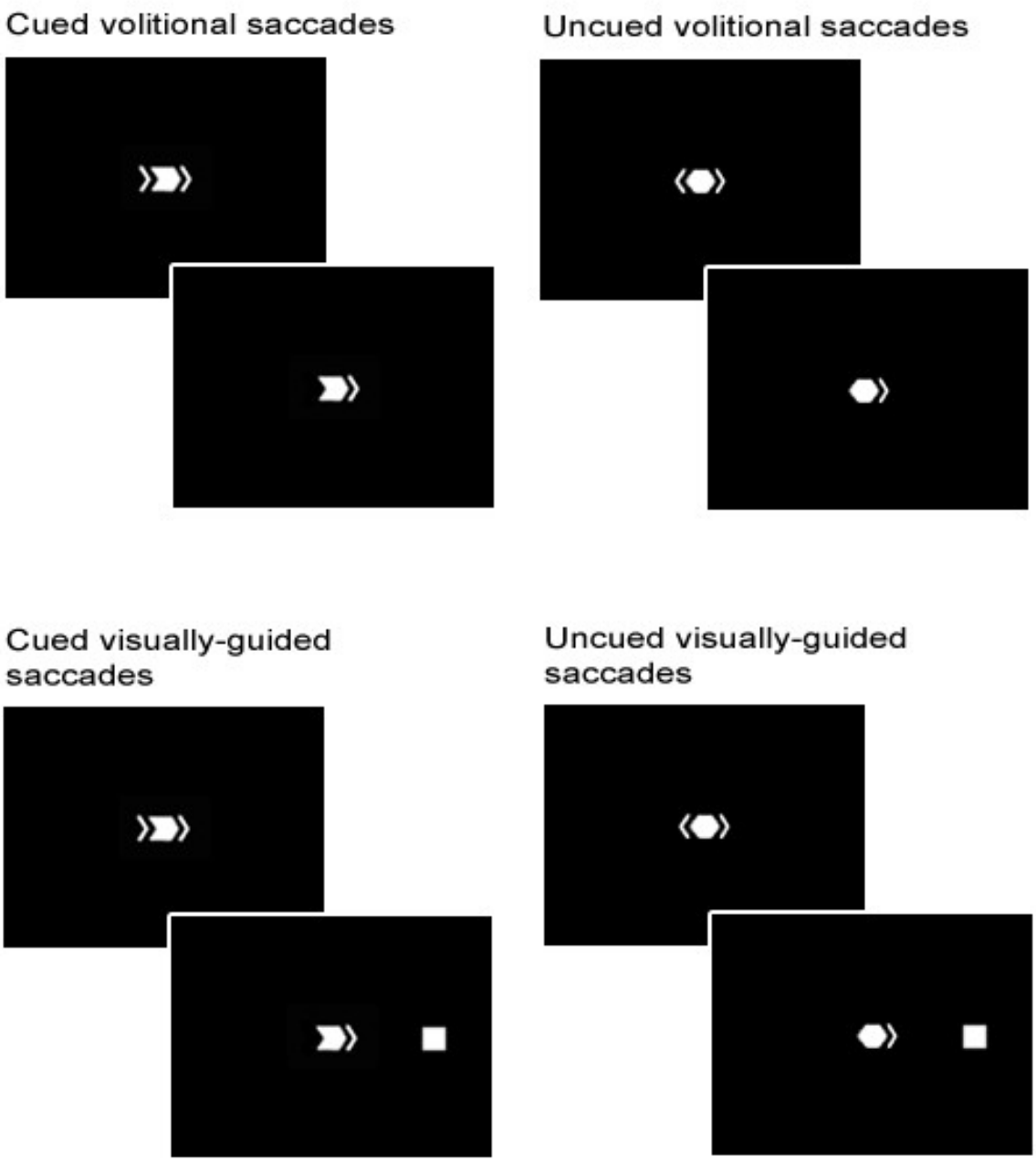

Figure 1: representation of the task conditions

(adapted from Kloft et al., 2013, with permission)

Cued visually-guided saccade

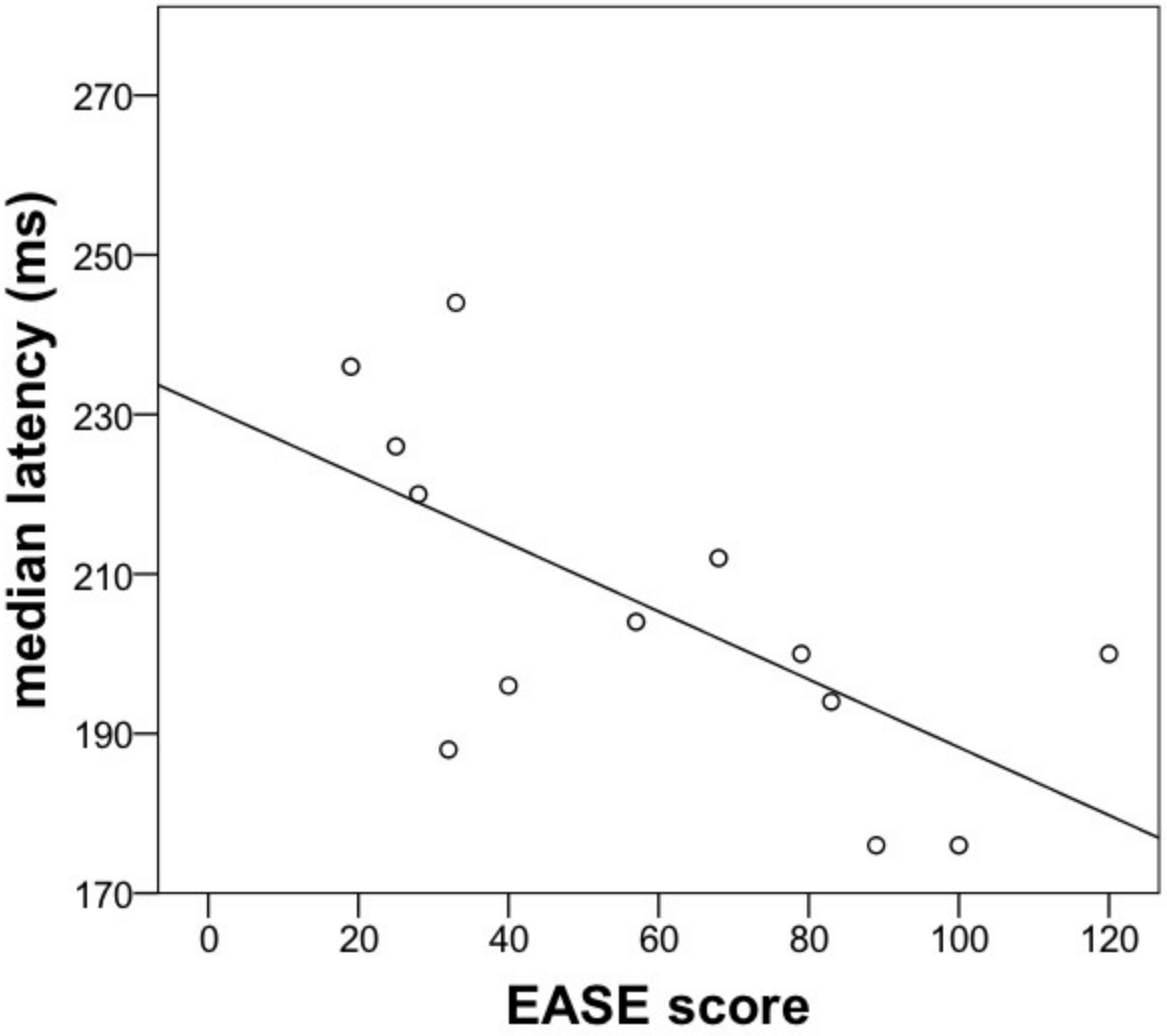

Figure 2: Scatter plot of latencies for cued visually-guided saccades (in ms) versus EASE score in the high-schizotypy group (N=13), r(11)=-0.66, p=0.02.

Uncued visually-guided saccade

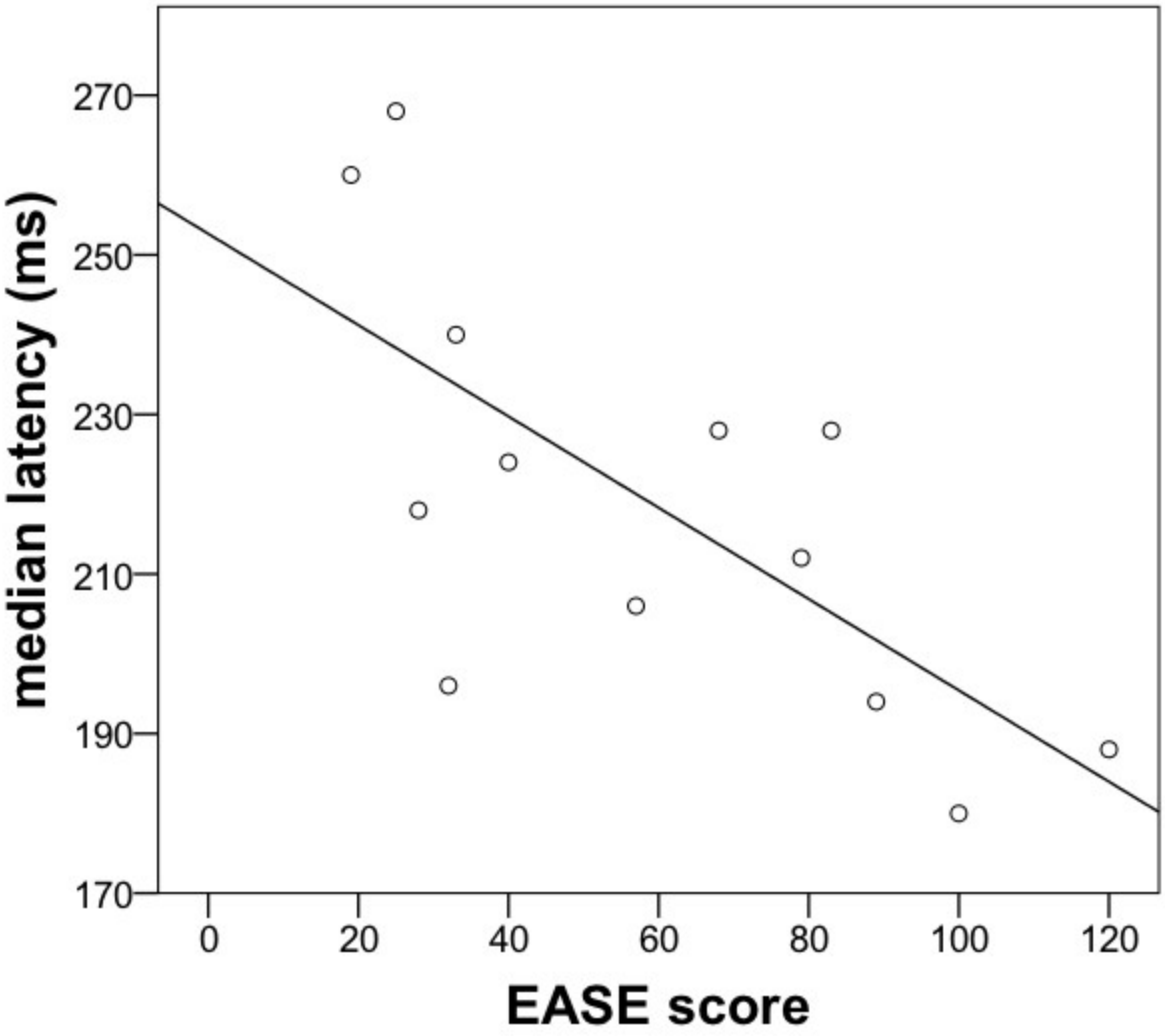

Figure 3: Scatter plot of latencies for uncued visually-guided saccades (in ms) versus EASE score in the high-schizotypy group (N=13), r(11)=-0.70, p=0.01.

7. Academic CV

Georgina Torbet

Berlin School of Mind and Brain, Luisenstraße 56, 10115 Berlin; georgina.torbet@gmail.com

Research Interests

My principle research interests are unusual experiences of self and agency in the schizophrenic spectrum. My current research uses an interdisciplinary approach involving methods from both experimental psychology (using eye tracking to implicitly measure disruptions of agency) and from phenomenological psychiatry (using interviews to assess disorders of self).

Education

PhD Psychology

2011 - present: Berlin School of Mind & Brain, Humboldt-Universität zu Berlin
Title: Disorders of agency and self in the schizophrenic spectrum
Supervisors: Professor Norbert Kathmann (Humboldt-Universität zu Berlin)
Professor Michael Pauen (Humboldt-Universität zu Berlin)

MSc Cognitive Neuroscience

2009 - 2011: University College London & Birkbeck, University of London
Thesis: Sub-Conscious Stimuli Can Induce Directed Forgetting: Cognitive neuroscientific approaches to Freudian repression
Supervisor: Dr. Katerina Fotopoulou (King's College London)
Award: Pass with Merit

MSc Philosophy of Mental Disorder

2007 - 2008: King's College London
Thesis: A Phenomenological Perspective on Schizophrenia: Disunity of self and disorientation in time.
Supervisor: Professor Derek Bolton (King's College London)
Award: Pass with Merit

BA Philosophy

2003 - 2006: University of Southampton
Thesis: Is Jaspers' definition of delusion adequate?
Supervisor: Dr. Denis McManus (University of Southampton)
Award: 2:1

Peer-Reviewed Publications

Torbet, G., Reuter, B., and Kathmann, N. (2014) Experimental methods of measuring agency: Conceptual aspects and implications for psychopathology research. Under review, *Phenomenology & the Cognitive Sciences.*

Torbet, G., Schulze, D., Fiedler, A., Kathmann, N., and Reuter, B. (2014) Reliability of measuring self disorders in a non-clinical population. Submitted for publication, *Schizophrenia Research.*

Torbet, G., Kathmann, N., and Reuter, B. (2014) Volitional and visually-guided saccades in non-clinical schizotypical populations. In preparation for publication, *Psychophysiology.*

Conference Talks & Poster Presentations

Conference Talks

Brighton, July 2012: Association for the Scientific Study of Consciousness meeting
Sense of Agency in Schizophrenia

Symposium Talks

Berlin, March 2014: Mind, Brain & Body Symposium, Mind-Brain Institute
Measuring Disorders of Self in the Non-Clinical Population

Venice, April 2013: Neuro-Philosophical workshop: Why do humans reason?
Social Context, Agency and Rationality

Venice, April 2011: Current Issues in Philosophy and Neuroscience
Cognitive Neuroscientific approaches to Freudian Repression

Poster Presentations

Berlin, January 2014: Mind and Brain Poster Presentation
What's the Problem with the Comparator Model?

Grenada, July 2013: European Society for Philosophy and Philosophy annual meeting
Disturbances of Agency in Schizophrenia

Berlin, November 2012: Mind and Brain Poster Presentation
Measuring Anomalies of Self in the General Population

Berlin, May 2012: Personal and Shared Intentions workshop
The Intentional Binding Paradigm: An Implicit Measure of Disturbances of Agency

Berlin, February 2012: Mind and Brain Poster Presentation
Agency and Selfhood in Schizophrenia

Workshop Participation

Munich, March 2013: Workshop participant: Visions for Neurophilosophy

Berlin, May 2012: Workshop participant and co-organiser: Dimensions of Delusions

Non Peer-Reviewed Publications

Research Digests

Self and Other, Neuropsychoanalysis, 2013, 15 (2)
Interdisciplinary critique, Neuropsychoanalysis, 2013, 15 (1)
Bias and Prejudice, Neuropsychoanalysis, 2012, 14 (2)
Methodologies and Dissemination, Neuropsychoanalysis, 2012, 14 (1)
Reflection and Representation, Neuropsychoanalysis, 2011, 13 (2)
Six Impossible Things Before Breakfast, Neuropsychoanalysis, 2011, 13 (1)

Awards

Mind and Brain Scholarship, Berlin, May 2011: Recipient of a full scholarship.
Women's Travel Award, November 2009: Award from Berlin School of Mind & Brain.

Teaching Experience

King's College London, 2010: Statistics & Research Methods
Taught on the Intercalated BSc in Psychology on good experimental practice.
Institute of Cognitive Neuroscience, 2009: Introduction to Neuroimaging methods
Taught an introduction to Bayesian probability in the context of neuroimaging.

Administrative Experience

Institute of Psychiatry, King's College London, 2008 - 2011:
Lead Administrator, Doctorate in Clinical Psychology
Institute of Psychiatry, King's College London, 2008:
Temporary Administrator & Assistant to Professor Elizabeth Kuipers, Head of Psychology

Training

Humboldt Graduate School soft skills training, Berlin, 2011 - 2013:
Trained in Scientific Presentation, Scientific Writing, Publishing Research Articles, Good
Scientific Practice, Writing Review Articles and Grant Application Writing.

EASE (Examination of Anomalous Self-Experience) training, Copenhagen, 2011:
Trained in semi-structured interview technique to assess self disorders (*Ich-Störung*) among patients with schizophrenia.

MATLAB training, Berlin, 2011:
Trained in the use of MATLAB software for constructing and presenting stimuli, recording
and analysing data, statistical analysis, and visualisation of results.

Other duties

Co-Organiser of the Dimensions of Delusions workshop, May 2012:
Assisted with the organisation of an interdisciplinary workshop on delusions, which included contributions from philosophers, psychiatrists and neurobiologists.

DFG Excellence Initiative funding application, January 2012:
Member of the defence committees for the Berlin School of Mind and Brain and the Humboldt University, both of which were successful in securing further funding from the German Research Foundation's Excellence Initiative.

Resident Journal Research Digest Reviewer, 2011 - 2013:
Wrote regular reviews of recent literature in the fields of neuroscience, psychology and psychoanalysis for the Neuropsychoanalysis journal.

References

Prof. Dr. Norbert Kathmann
Head of Clinical Psychology
Raum 0'221, Klinische Psychologie
Institut für Psychologie
Humboldt-Universität zu Berlin
Rudower Chaussee 18
12489 Berlin. +49 30 2093 4903
kathmann@rz.hu-berlin.de

Dr. Katerina Fotopoulou
Senior Lecturer
University College London
Division of Psychology and Language Sciences
Floors 3-5
1-19 Torrington Place
London WC1E 6BT.
a.fotopoulou@ucl.ac.uk

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To my other friends in Berlin and in London who helped me though this: Trim, my partner in crime; Emma, my little sister; and Nancy, my rock in stormy seas. To Sebastian for never failing to make me smile, and to Andy, Leon and Marko for welcoming me to the group and taking me on fantastical adventures.

To Derek Bolton, whose wonderful teaching inspired me to go into psychopathology research, and to Dave Hemsley, whose support and mentorship got me here.

Thank you. For making this experience interesting, challenging, and so much fun, thank you.